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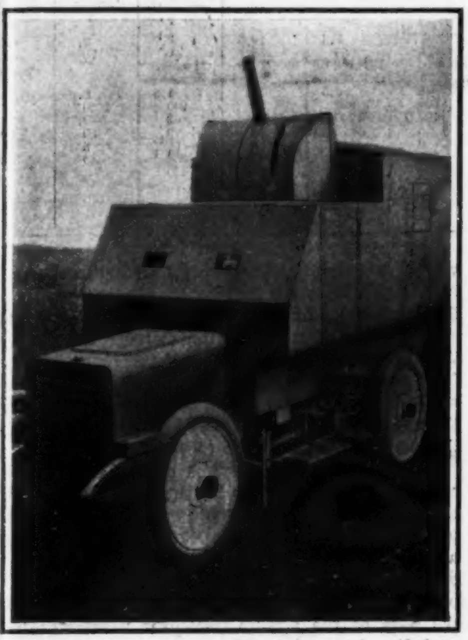


FIG. 1.—EHRHARDT ARMORED AUTOMOBILE CARRYING A 2-INCH RAPID-FIRE GUN FOR DESTROYING AIRSHIPS.

FIG. 3.—KRUPP 4.2-INCH GUN WITH NAVAL MOUNT.

FIG. 9.—KRUPP 2.8-INCH GUN IN COMPLETELY ARMORED AUTOMOBILE.

FIG. 10.—KRUPP 2.8-INCH GUN IN HALF ARMORED AUTOMOBILE.

FIG. 2.—KRUPP 3-INCH AUTOMOBILE GUN.

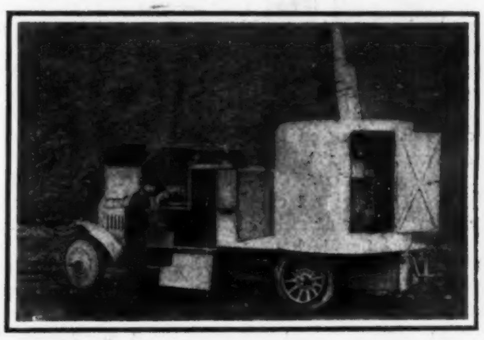


FIG. 11.—KRUPP 2.8-INCH GUN IN SLIGHTLY ARMORED AUTOMOBILE.

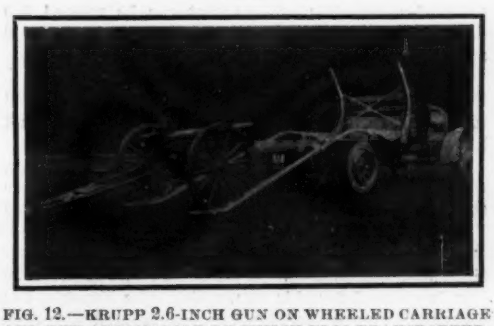


FIG. 12.—KRUPP 2.6-INCH GUN ON WHEELED CARRIAGE AND THE AUTOMOBILE BY WHICH IT IS TRANSPORTED.

FIG. 4.—KRUPP 2.6-INCH GUN MOUNTED ON WHEELED CARRIAGE.

FIG. 5.—FIRING POSITION OF THE GUN AND CARRIAGE SHOWN IN FIG. 4.

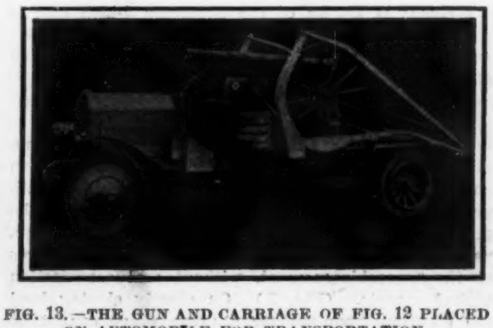


FIG. 13.—THE GUN AND CARRIAGE OF FIG. 12 PLACED ON AUTOMOBILE FOR TRANSPORTATION.

GUNS FOR ATTACKING AIRSHIPS.

GUNS FOR ATTACKING AIRSHIPS.

A REVIEW OF PRESENT SOLUTIONS OF THE PROBLEM.

The problem of destroying or driving away hostile airships is being seriously discussed by military experts. The present state of the problem and its chief technical and tactical peculiarities are here briefly reviewed.

The great difficulty of hitting an airship makes the usual methods of warfare inadequate. The fire of infantry and even that of machine guns are of little use, despite their momentary mass effect, because of the limited range and effectiveness of the projectiles and the impossibility of observing their flight. Field and siege guns cannot be elevated sufficiently and howitzers are deficient in range and rapidity of fire, while all of these classes of artillery are lacking in horizontal angular range and visibility of projectiles. The correctness of this view has been confirmed by experiment.

Special guns, therefore, are required for combating airships. Various types of such guns have been constructed by the Ehrhardt, Krupp, Schneider, Skoda, Vickers, and other private firms. Of guns constructed for this purpose in governmental workshops only two of American make can be mentioned, a 2-inch, 30-caliber gun and a 3-inch gun, both mounted on wheeled carriages, which are said to have been tried without success against captive balloons in 1909.

Guns employed for attacking airships must possess a maximum elevation of at least 70 deg., a horizontal angular range of 360 deg., and the possibility of rapid change of direction. In Ehrhardt's 5-centimeter (2-inch) automobile gun (Fig. 1) an attempt is made to satisfy these requirements by aiming the gun, which is supported at its center of gravity, by the movement of a shoulder rest to which the sights are attached. This method gives a maximum elevation of 70 deg. The gun is mounted in an armored turret with a lateral range of 60 deg. to right and left, which is carried by an armored automobile. The same gun is also mounted on an automobile of which only the lower part is armored, so that the horizontal angular range is 360 deg.

For the war against airships Krupp employs guns of 6.5, 7.1, 7.5, and 10.5 centimeters caliber (2.6, 2.8, 3.0, and 4.2 inch) with the trunnions near the breech and a maximum elevation of 75 deg. For use on automobiles, ships and fortifications the guns are mounted on carriages which rotate on pivots (Figs. 2 and 3). The same firm constructs for field use a wheeled carriage with its axle made in two parts which are attached by hinge joints to the front of the long carriage, the rear end of which is pivoted to a rail resting on the ground. (Fig. 4.) If both wheels are brought in front of and beneath the gun, as shown in Fig. 5, and locked in that position, the gun can be revolved entirely around the pivot, so as to point in any direction, by turning the wheels with the hands. Small changes of direction are produced by means of an upper carriage which can be turned 5 deg. to right or left. The durability of this construction has been proved by extensive trial trips.

The Schneider firm has designed a 4.7-centimeter (1.9-inch) 60-caliber gun mounted in an armored turret which is carried on the top of a completely armored automobile. The turret can be rotated 360 deg., and the gun can be elevated 70 deg. (Figs. 6 and 7.)

The Skoda firm has designed a 3.7-centimeter (1.5-inch), 70-caliber gun. The maximum elevation is said to be 80 deg., but the details of construction are not known.

The Vickers firm, which, according to report, has constructed a 15.2-centimeter (6-inch) field howitzer suitable for use against airships, recently published the design of a 4.7-centimeter (1.9-inch) gun (3-pounder) mounted on a pivot, for use on ships, fortifications and automobiles. A maximum elevation of 90 deg. is claimed for this gun, which, like Krupp's, has its trunnions near the breech and is elevated by a rack and pinion. (Fig 8.)

All that is known of the American 3-inch gun is that it is mounted on a carriage with small wheels and can be turned in any direction with an elevation of 60 to 70 deg.

The aiming mechanism of a gun employed against airships must be able to follow every movement of the swiftly flying adversary. With Ehrhardt's gun this is effected by sighting, as with a rifle. Krupp employs two parallel and connected telescopes, with verticals and reflecting eye-pieces. One man aims the gun with the aid of one telescope; the other man, using the second telescope, elevates the gun and fires at the favorable moment, without oral consultation with his mate. (Fig. 5.) On steeply sloping land the elevation required for a given range cannot be obtained accurately from the published tables, so the telemeter is used instead. The necessary rapidity of fire is obtained by means of a self-closing breech, while great range and accuracy of fire are secured by the employment of a long gun and great muzzle velocity. The following table contains the principal numerical data of the known guns designed for airship warfare:

Maker.	Ehrhardt.	Krupp.				Schneider.	Skoda.	Vickers.
Caliber, cm	5	6.5	7.1	7.5	10.5	4.7	3.7	4.7
Length in calibers	30	35	35	35	35	60	70	....
Mounting	Armored automobile	Wheeled carriage	Pivoted on automobile	Pivoted on automobile	Pivoted on shipboard	Armored automobile	....	Pivot.
Weight of projectile, kg.	2.4 | 1.5	4	5	5.5	14	1.5	0.8	....
Muzzle velocity, meters	450 | 572	620	650	625	795	900	1000	....
Muzzle energy, meter-tons.	24.8	78.5	107.5	109.5	450	62	40.77	....
Range of elevation, degrees	+ 70 − 5	+ 70 5	+ 75 − 0	+ 75 − 0	+ 75 − 0	+ 70 − (?)	+ 80 − 5	+ 90 − (?)
Horizontal angular range, degrees	60	360	360	360	360	360	360	360
Maximum vertical range, meters	3720	5700		6300	11,400	5600		
Maximum horizontal range, meters	7800	8650	....	9100	13,500	....	....	....
Weight of gun, kg.	400	875	....	1065	3,000		615	
Total weight of gun and automobile, kg	3200	..	....	4315	....	6000	....	....

In airship warfare the question of ammunition is particularly important. Shrapnel is not well suited to the purpose. With a large number of bullets and fragments the gas bag may be cut, allowing the gas to escape, but while serious damage may thus be done to airships of the flexible and semi-rigid types, in which the gas is confined under considerable pressure in order to give stiffness, several of the separate gas bags of an airship of the rigid type might be pierced without sinking the vessel. Nor can complete success be reasonably expected from the shrapnel connected by chains 8 or 10 inches long which has been employed in Italian experiments, or from shrapnel provided with rotating blades and fuses for the purpose of cutting the bag and igniting the gas. An additional difficulty in the employment of shrapnel is involved in determining the proper length of the time fuse, which does not agree with the tabular time of flight corresponding to either the measured distance of the object of attack or the distance deduced from the angle of fire. The setting of the time fuse, therefore, requires calculation, which is incompatible with rapid firing. The fuse, also, burns very irregularly in the upper atmospheric strata of varying density which the projectile may have to traverse.

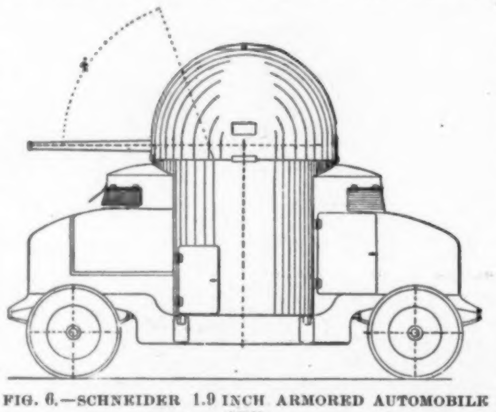


FIG. 6.—SCHNEIDER 1.9 INCH ARMORED AUTOMOBILE GUN.

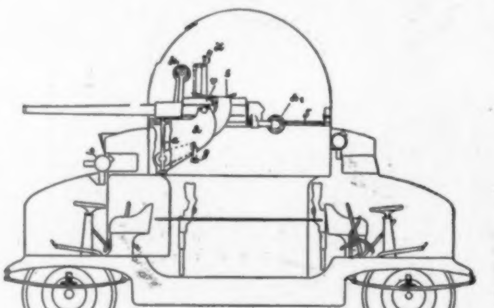


FIG. 7.—DIAGRAM OF SCHNEIDER AUTOMOBILE.

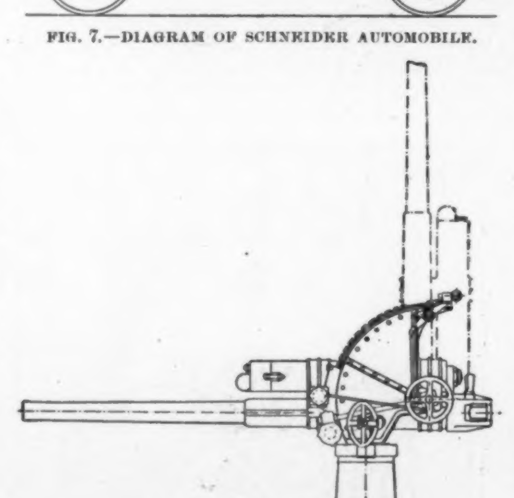


FIG. 8.—VICKERS 1.9-INCH GUN MOUNTED ON PIVOT.

GUNS FOR ATTACKING AIRSHIPS.

The most promising method of attack, therefore, is apparently to endeavor to hit the airship directly with shells and destroy it by their explosion and the scattering of their fragments. Ehrhardt has constructed a shrapnel shell provided with a fuse for the ignition of the balloon gas. Krupp's shell has a contact exploder sensitive enough to be operated by impact upon the skin of the airship, which it penetrates before exploding in the interior. In the gun this very sensitive exploder is prevented from operating by a mechanical device. A special slowly-burning fuse reveals the course of the projectile by its light at night and a trail of smoke by day.

In this connection it is appropriate to refer briefly to the method of firing. As the hostile airship is usually visible for a very short time only and sometimes moves very swiftly it cannot be hit by direct aiming, even with the easily observed fire shells. In order to utilize fully the few favorable moments, a number of shots should be fired in rapid succession, varying slightly in direction and elevation, but aimed in general accordance with the measured or estimated distance, with proper allowance for the slope of the land, and corrections based on observation of the visible flight of the successive shots.

The caliber of the gun varies from 3.7 to 10.5 centimeters (1.5 to 4.2 inches), according to the purpose for which it is designed. The effectiveness of the Skoda 3.7-centimeter (1.5-inch) gun, with its projectile weighing only 0.8 kilogramme (1.7 pounds), is questionable, and the same remark applies to the 4.7-centimeter (1.9-inch) guns of Schneider and Vickers. The calibers most suitable for field work appear to be between 6 and 7.5 centimeters (2.4 and 3 inches). These calibers combine the requisite mobility of the gun with an effective explosive action, and also allow shrapnel to be employed. Although shrapnel appears to be ineffective against airships, as was pointed out above, the possibility of employing it is an advantage, as it makes the gun useful for other field work. Krupp selects a caliber of 10.5 centimeters (4.2 inches) for guns mounted on ships and fortifications.

In addition to these technical peculiarities, certain tactical points must be considered. Movable guns employed in the war against airships must possess great mobility, in order that they be transported rapidly from place to place to destroy scouting airships. The automobile at once suggested itself and, on superficial consideration, it appears to satisfy every requirement. It can travel a great distance in a short time, it can be made strong enough for all military purposes, it is always ready to start, it allows the employment of the central pivot mounting which is especially well adapted for guns employed against airships, it is able to carry the gunners and the ammunition, and it can carry armor for the protection of its contents, passengers and mechanism.

An automobile thus constructed, armed, armored, manned and equipped, however, would be so heavy that its speed could not greatly exceed 30 miles per hour. Hence, to judge from experiments made with drifting balloons, it would be almost useless for pursuing airships, which are able to travel 40 miles per hour with a favorable wind. Moreover, streams and

other obstacles would often necessitate long detours or block the pursuit entirely. So heavy an automobile requires good roads, which are not found everywhere, even in western Europe. It cannot leave the road and climb a hill whence the airship might be sighted and destroyed, and even a good road may be put, by rain, snow or the passage of an army, into a condition which would greatly retard the progress of the heavy vehicle.

The addition of heavy armor enables an automobile, unsupported by troops, to withstand the enemy's fire, but this advantage is accompanied by serious disadvantages. Very heavy armor is required to assure protection against rifle fire at close range. The first Ehrhardt automobile (Fig. 1) was entirely inclosed, with the exception of a narrow slit, in armor, which, however, was only ¼ inch thick. Hence it was impossible to see over a wide field, which is especially necessary in airship warfare. The armor hood could be raised in action, but this would involve danger and almost destroy the advantage of carrying the impeding armor. Furthermore, the cramped quarters and hot atmosphere inside the armor shell would irritate the nerves and impair the efficiency of the gunners.

For these reasons complete armoring appears inadvisable for rapid work. It is sufficient to protect the officer who acts as driver, and the motor, wheels and gasoline tank, on which the mobility of the car depends. This protection can be given without very greatly increasing the weight. Ehrhardt's newer automobile (Fig. 2) is only half armored, and Krupp's cars (Figs. 9, 10, and 11) are made both with and without armor. Schneider's design for an armored automobile (Figs. 6 and 7) includes a driver's seat, with complete steering apparatus, at the rear end of the car, which can therefore quickly reverse its motion, without turning.

The disadvantages of the automobile are avoided by mounting the gun on a wheeled carriage which, though it cannot travel a great distance in a short time, can traverse any passable ground as readily as an ordinary field-piece. Each gun must be accompanied by an ammunition wagon, containing about 140 rounds and weighing about 3,500 pounds.

Figs. 12 and 13 illustrate another Krupp construction, in which the wheeled carriage is combined with the automobile. For transportation, the gun and its carriage are hauled to the platform of the automobile by means of inclined rails and a winch, and secured by turning up the rails. On arriving at the scene of action the gun and carriage are replaced on the ground and can be moved by the crew for short distances over obstacles which the automobile cannot pass. Probably the solution of the problem of mobility will be found in this happy combination of the automobile with the wheeled gun carriage.

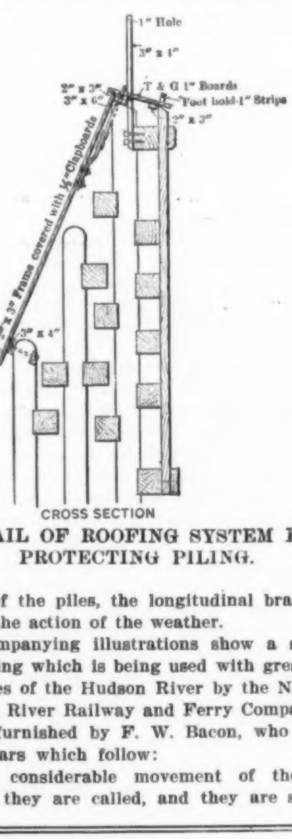
For use in extended fortifications possessing good interior roads, where it will often be necessary to move the gun quickly from one side to the other in order to repel scouting airships, the gun should be permanently mounted on an automobile which should carry armor to protect it from the fire of the enemy's outposts. Many such automobile airship destroyers should be provided for forts, since these will be the chief places of interest to the enemy's aerial spies. Airship harbors within fortifications should be protected against hostile airships by airship-destroying guns of large caliber (such as the Krupp 4.2-inch) mounted on central pivots in fixed emplacements.

In the field, guns mounted on wheeled carriages are preferable, for the reasons given above. Many such guns should be sent forward with the cavalry and mounted artillery, for the purpose of paralyzing at the outset the activities of the enemy's aerial spies. These guns should also be distributed among the field artillery, in the proportion of at least one to each regiment, so that they will be scattered along the entire front of the army and some of them will always be available for use where they are needed.—Artilleristische Monatshefte.

ROOFING FOR FERRY-SLIP PILES.

A NEW IDEA IN PILES.

The rapid deterioration of the pine and oak piling that forms the guide walls of ferry slips or landings, is a cause of much expense and endless renewals. This loss is due to the common practice of leaving the heads of the piles, the longitudinal bracing, etc., exposed to the action of the weather.



CROSS SECTION

DETAIL OF ROOFING SYSTEM FOR PROTECTING PILING.

The accompanying illustrations show a system of flexible roofing which is being used with great success on both sides of the Hudson River by the New Jersey and Hudson River Railway and Ferry Company. They have been furnished by F. W. Bacon, who sends us the particulars which follow:

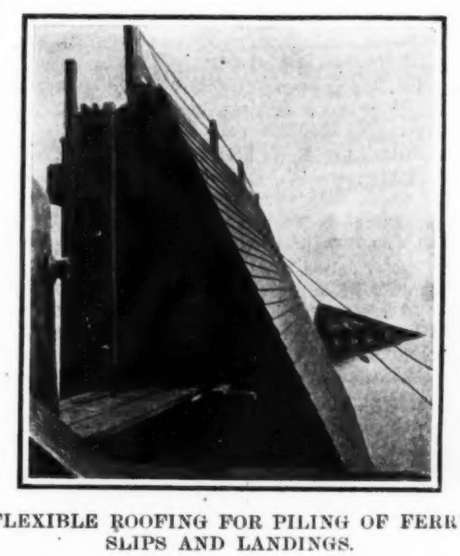
There is considerable movement of these ferry "racks," as they are called, and they are subject to heavy shocks from the continuous landing of boats. Therefore, everything pertaining to this construction must be exceedingly flexible, yet substantial enough to withstand this racking. The rack cover proper is built in 12-foot sections, this being determined upon as about the maximum width of section that could be handled easily without making it too cumbersome. The cover, a plain frame with clapboarding, is supported by a chain connection through eyebolts on the upper cord, which cord is run parallel to the rack on the upper tier of piles. There are three of these chain supports to each section, the two outside chains being set at a slight angle, so as to adjust any lateral movement in the roof. The roof rests similarly against a cord on the lower tier of piles, which acts as a rubbing piece and, as the rack proper sways back and forth, the roof slides up and down. It has the same flexibility on the upper cord but, of course, the movement at that point is very small.

In case it is desirable to make any repairs to the rack structure, the nuts on the eyebolt are run off and the roof sections are laid aside in the river for the time being so that there is no material labor in getting at any section of the rack.

The engravings show a type of roof adapted to a class of rack where the three rows of piles have been carried at a high elevation. In general, the rear row of piles is lapped about 12 inches, this point being above high water, thus avoiding any damage to the structure by ice or deterioration due to the tides rising over the roof.

It has not been found necessary to cover the air streaks between the different sections of the roof, as the roof is laid very close together, and the quantity of water that gets through these small streaks is a matter of no consequence. The roof is absolutely tight and, during severe storms, protects and keeps the timber in the structure perfectly dry.

The company's experience with piling on its property has been that wherever a pile is covered by a roof of any character, or is even situated along the edge of a roof, it has had to make absolutely no replacement, nor have any piles rotted or shown any inclination to rot after sixteen years of service. Where this timber is exposed to the weather it is not usual to get more than eight to nine years' maximum life out of the pine piles or more than ten to twelve years out of the oak timber in the rack.



FLEXIBLE ROOFING FOR PILING OF FERRY SLIPS AND LANDINGS.

The company has had these covers in service since last August, and it has had no trouble with them whatsoever. The structure seems to be thoroughly practical, and to be working out very satisfactorily. This cover complete, installed, cost $3.75 per running foot, including the walkway on the top, or 15.4 cents per square foot.

TESTS OF A MILWAUKEE DESTRUCTOR.

In the Engineering Record, an account is published of some tests made with a Milwaukee refuse destructor. The apparatus is a Heenan refuse destructor, designed to burn 300 tons daily, arranged in four furnaces each having six grates, three on each side of a central combustion chamber. The clinkering and operating is done on the ground-floor level, where also the offices, electrical machinery, and recording instruments are located. The upper story is used as a feeding floor and for storage of refuse. The refuse is hoisted into the building and distributed by two electric overhead cranes, whose tracks extend out beyond each end of the building. The basement is used for the clinker railway, doors for cleaning dust from furnaces, and the men's washroom. The refuse is collected in two classes of carts. The one-horse carts are for garbage, and have removable steel bodies of about 1¼ cubic yards' capacity. These car bodies are hoisted up, and their contents discharged on to the feeding floor. The two-horse wagons are of 2½ cubic yards' capacity, and they collect rubbish and ashes which they dump into boxes resting in pits at ground level. The boxes are then picked up by the cranes, and their contents transferred to the storage bins. The material when dropped into the furnace falls on to a drying hearth, where a large proportion of the moisture is carried away by hot gases. The fireman then rakes the dried material forward on to the grates as required, small stoking doors being provided for this. After a sufficient amount of material has been burnt on each grate to form a thick body of clinker, a large counterweighted clinkering door in the front is opened, and the clinker, after being broken up by bars, is drawn forward and dropped through holes in the floor into steel dumping cars below.

After leaving the combustion chamber the hot gases pass over the heating surface of a 200-horsepower water-tube boiler, and then through an air heater or regenerator to the chimney. Combustion is entirely controlled by forced draught, all the air being drawn through an air-heater by an engine-driven fan, and raised to over 300 deg. F. The proportions are such that the amount of air required for combustion when the plant is operating at full capacity is several times greater than the cubic contents of the building. This insures the renewal of all the air in the building every 8 minutes, and prevents the escape of any gas except through the chimney. The following are some of the more important features: The garbage is stored by itself away from ashes and rubbish, and the free water, amounting to 7 to 9 per cent, is then drained away to the sewer. The effectiveness of the drying hearth is increased by the hot gas duct, extending along the back of the hearth. The hearth increases the life of the fire-grate because it receives the impact of the refuse; it is of substantial brick construction. The mechanical charging devices make it unnecessary to do any hand firing with wet, dirty refuse. Each operation is performed separately from every other; thus the cranesmen work at top speed without interference from men on the feeding and mixing floor, and the latter are not hindered by the men stoking the furnaces. Similarly the firemen work in a room to themselves. The article is well illustrated, and particulars are given of three tests made with normal, extreme winter, and with extreme summer refuse.

PRACTICE AND THEORY OF AVIATION.—IV.*

THE LEADING AEROPLANES.

BY GROVER CLEVELAND LOENING, A.M.

Continued from Supplement No. 1818, Page 302.

11. THE BLÉRIOT XII. MONOPLANE.

M. Blériot has also designed a passenger-carrying type of monoplane, the No. XII., which differs in structure from the No. XI. A type similar in form to the No. XII. is the small No. XIII., with which M. Blériot attained high speed at Rheims in 1909.

On June 12th, 1909, the first flight of an aeroplane carrying three passengers was accomplished by M. Blériot on his large No. XII. The machine has since then become almost as popular as the No. XI., and more than thirty aeroplanes of this type are now in use.

The Frame.—The long central frame of wood braced in every panel by cross wires is very deep at the front and tapers gracefully to a point at the rear.

The Supporting Plane.—On the upper deck of the central frame at the front is placed the main plane, which is continuous and perfectly horizontal. The plane is braced by wires from the frame and its structure is similar to that of the Blériot No. XI. The spread is 30.2 feet, the depth is 7.6 feet, and the surface area is 228 square feet.

The Direction Rudder.—A single surface placed at the rear extremity of the vertical keel is used as the direction rudder. Its area is 9 square feet and it is operated by a foot lever as in No. XI.

The Elevation Rudder.—The elevation rudder consists of a single surface, placed at the extreme rear and 20 square feet in area. It is operated by the front and back motion of the "bell-crank."

Transverse Control.—To preserve the lateral balance the main surfaces are warped inversely by the side to side motion of the "bell-crank," exactly as in No. XI. A small surface under the seat also aids in lateral balancing.

Keels.—A horizontal keel of 21 square feet area is placed on the framework at the rear but somewhat in front of the elevation rudder.

Propulsion.—A 60 horse-power 8-cylinder E. N. V. motor is placed in the frame under the main plane. This motor drives by a chain transmission a single 2-bladed Chauviere propeller, the axis of which is placed on the edge of the main plane. This propeller is 8.8 feet in diameter and 9 feet pitch, and turns at 600 r.p.m.

The Seat or bench for three is placed in the frame under the main plane and back of the motor.

The Mounting is similar to that on No. XI.

The total weight is from 1,150 to 1,300 pounds. The speed is 48 miles per hour; 21 pounds are lifted per horse-power and 5.3 pounds per square foot of surface. The aspect ratio is 4 to 1.

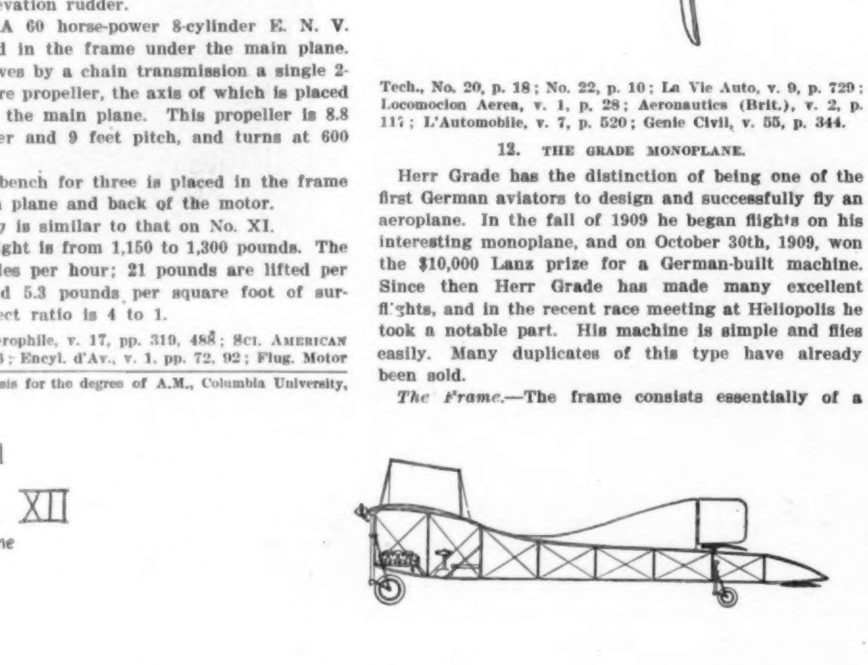
References.—Aerophile, v. 17, pp. 319, 488; Sci. American Sup., v. 68, p. 136; Encyl. d'Av., v. 1, pp. 72, 92; Flug. Motor Tech., No. 20, p. 18; No. 22, p. 10; La Vie Auto, v. 9, p. 729; Locomocion Aerea, v. 1, p. 28; Aeronautics (Brit.), v. 2, p. 117; L'Automobile, v. 7, p. 520; Genie Civil, v. 55, p. 344.

* Accepted as thesis for the degree of A.M., Columbia University, June, 1910.

N° 11

Bleriot XII

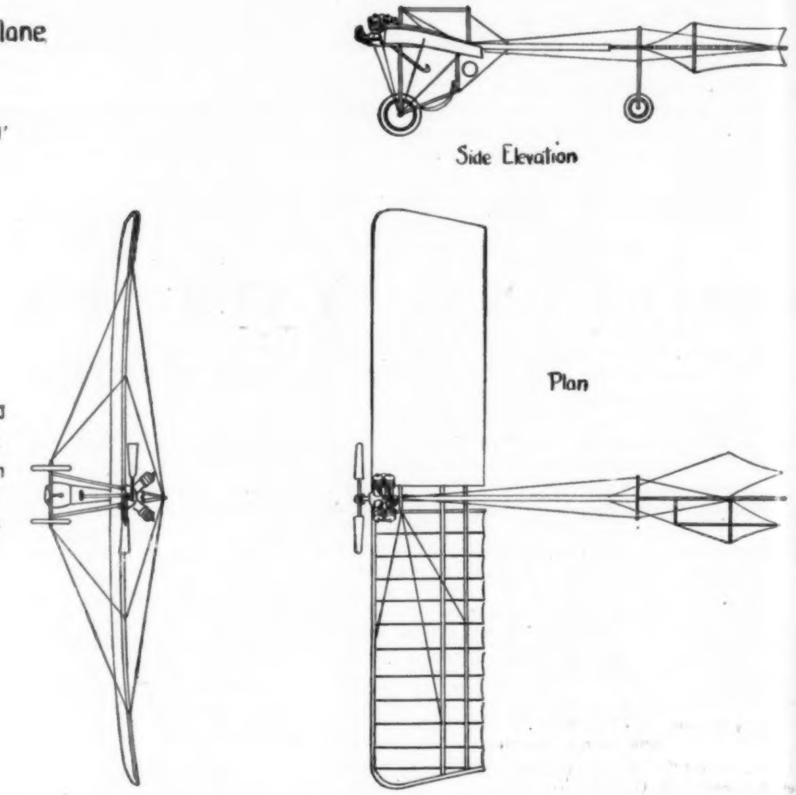
Monoplane



N° 12

Grade Monoplane

Scale 1/8" = 1'



12. THE GRADE MONOPLANE.

Herr Grade has the distinction of being one of the first German aviators to design and successfully fly an aeroplane. In the fall of 1909 he began flights on his interesting monoplane, and on October 30th, 1909, won the $10,000 Lanz prize for a German-built machine. Since then Herr Grade has made many excellent flights, and in the recent race meeting at Heliopolis he took a notable part. His machine is simple and flies easily. Many duplicates of this type have already been sold.

The Frame.—The frame consists essentially of a main metal tube chassis at the front, from which a long thick piece supporting the rudders is run out to the rear.

It is remarkable for its simplicity.

The Supporting Plane.—The main surface is made of Metzeler rubber fabric stretched over a bamboo frame. The surface is very flexible and the two ends are slightly turned up from the center. The curvature is almost the arc of a circle and the surface is very thin. The spread is 30 feet, the depth 7 feet, and the area 208 square feet.

The Direction Rudder.—The direction rudder consists of a single flexible surface of about 16 square feet area, carried at the rear and controlled by a lever operated by the aviator. The surface is not hinged, but is merely bent by the controlling wires in the desired way.

The Elevation Rudder.—The elevation rudder consists also of a single flexible surface placed at the rear. Its area is about 20 square feet and it is operated by a large lever universally pivoted on the frame above the aviator. To rise, this lever is pulled up, and to descend, it is pushed down, thus respectively bending up and bending down the rear horizontal surface.

Transverse Control.—The transverse control is effected by warping the main surfaces. This is accomplished through wires leading from the large lever. Side to side motion of this lever warps the surfaces inversely. Thus if the machine tips down on the right, the lever is moved over to the left, thus raising the depressed side and depressing the elevated side.

Keels.—The tapering ends of both the direction and elevation rudders can be considered as keels. An additional vertical keel is placed in front, both above and below the main surface.

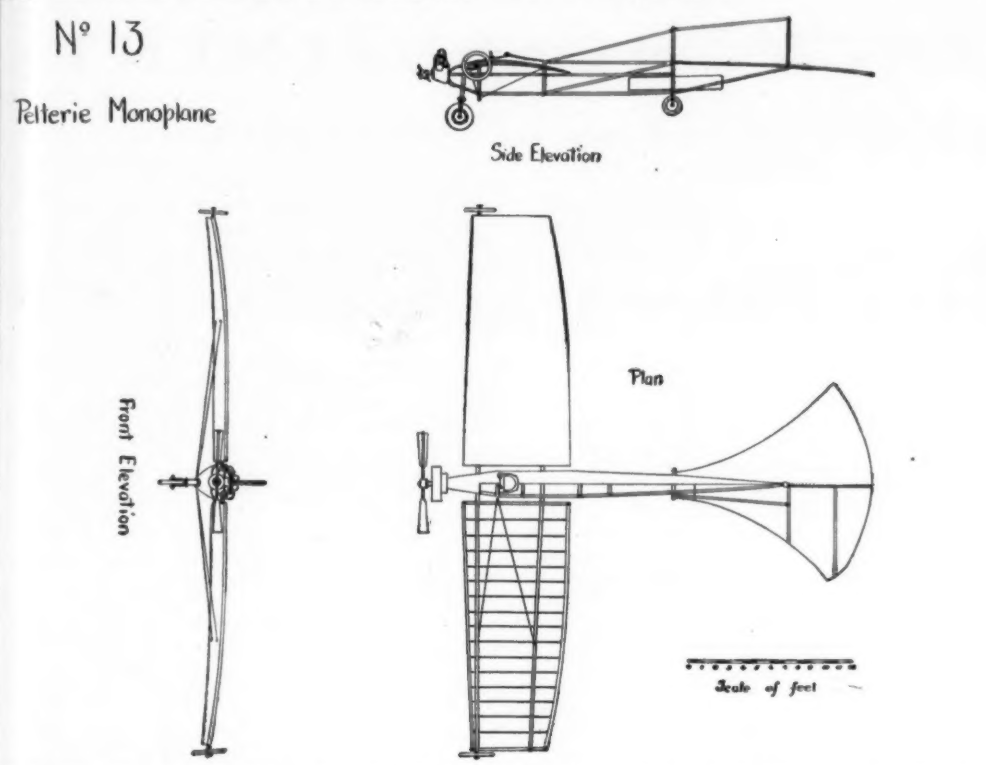
Propulsion.—A 4-cylinder 24 horse-power V-shaped motor is placed at the front edge of the plane. It drives direct at 1,000 r.p.m. a 2-bladed metal propeller 6 feet in diameter and 4 feet pitch.

The Seat is placed under the plane, and consists of a hammock-like piece of cloth which gives great comfort and little weight.

The Mounting is on two wheels at the front and a smaller one at the rear. There are no springs provided whatsoever on the chassis. The front wheels are fitted with a brake to bring the machine to a stop shortly after landing.

The total weight is from 350 to 450 pounds. The speed is approximately 44 miles per hour; 17 pounds are lifted per horse-power and 1.9 pounds per square foot of surface. The aspect ratio is 3.2 to 1.

References.—SCI. AMERICAN, v. 101, p. 292; Aerophile, v. 17, pp. 439, 508; Zeit. für Luftschiff, v. 13, pp. 802, 957; ...to, v. 1, p. 405; Motor Car Jour., v. 2, p. 794; La Vie ...to, v. 9, p. 711; Zeit. Ver. Deut. Ing., v. 53, p. 1762.



13. THE PELTERIE MONOPLANE.

The Pelterie monoplane is considered by many to be one of the most perfect types of aeroplanes. Great finish is exhibited in its construction and form, but due probably to motor troubles it has never been flown for any great length of time. M. Pelterie, the designer, is one of the foremost aviation scientists abroad, and previous to his experience with this machine he conducted a series of gliding experiments of great interest. M. Guffroy, as well as M. Pelterie, has flown this type several times.

The Frame.—The central frame, somewhat similar in shape to a bird's body, is made largely of steel tubing, and is quite short. All exposed parts are covered with Continental cloth.

The Supporting Plane.—The main surface is particularly strong and solid, and is made of steel tubing carrying wooden ribs covered with Continental cloth. The curvature is very similar to that of a bird's wing, and transversely the surface curves downward dihedrally from the center. There is very little bracing necessary. The spread is 35 feet, the depth 6.1 feet, and the area 214 square feet.

The Direction Rudder.—The rudder for steering from side to side consists of a vertical rectangular surface of 8 square feet area, placed below the central frame at the rear. It is operated by the side to side motion of the lever at the aviator's right hand. To turn to any side the lever is inclined to that side.

The Elevation Control.—There is no elevation rudder in the Pelterie monoplane, the elevation of the machine b 'ng regulated by changing the incidence of the main plane itself. To ascend, for example, the aviator pulls the lever in his left hand toward him. This increases the incident angle of the plane and the consequent increase of lift causes the machine to rise.

Transverse Control.—Each half of the main plane is warpable about its base, and transverse equilibrium is obtained by an inverse warping of the plane. The side to side motion of the left-hand lever controls the warping. If the machine is tipped down on the right and the lever is moved to the left and the machine brought back to an even keel. In turning to either side both the left-hand lever controlling the warping and the right-hand lever controlling the direction rudder are simultaneously moved to that side. This is a very effective controlling system.

Keels.—Vertical and horizontal keels, consisting of gradually tapering surfaces, are fixed to the frame and aid in preserving stability. The rear horizontal keel, shaped like a bird's tail, has an area of 20 square feet.

Propulsion.—A 7-cylinder 35 horse-power R.E.P. motor, placed at the front, drives direct a four-bladed aluminium and steel propeller at 900 r.p.m. The diameter of the propeller is 6.6 feet, and the pitch 5 feet.

The Seat is placed in the frame, and protected on all sides. The aviator's shoulders are flush with the surface.

The Mounting is mainly on a large single wheel with an oleo-pneumatic spring in the center at the front and a smaller one in the same center line at the rear. When first starting the aeroplane is inclined, resting on one end of the plane, on each end of which also a wheel is placed.

The total weight is from 900 to 970 pounds. The speed is 39 miles per hour; 27 pounds are lifted per horse-power, and 4.4 pounds carried per square foot of surface. The aspect ratio is 5.75 to 1.

References.—Soc. des Ing. Civ., v. 2 (1908), p. 13; Boll. Soc. Aer. Ital., v. 6, pp. 67, 288; Aerophile, v. 15, p. 331; v. 16, p. 226; v. 17, p. 33; Flight, v. 1, pp. 19, 360; Aeronautical Jour., v. 13, p. 64; Zeit. für Luftschiff, v. 12, p. 458; Aeronautics, v. 4, p. 21; La France Aerienne, v. 14, Nos. 7, 9; Zeit. Ver. Deut. Ing., v. 53, p. 1760; Genie Civil, v. 55, p. 346.

14. THE PFITZNER MONOPLANE.

In the early part of January, 1910, the remarkable monoplane designed by Mr. A. L. Pfitzner and built at the Curtiss aeroplane factory at Hammondsport, N. Y., was completed and flown. The first flights were short, due largely to the inexperience of the aviator, Mr. Pfitzner, but the monoplane is considered by many to be a very promising type.

This aeroplane is a distinct deparature from all other monoplanes in the placing of the motor, aviator, and rudders, and in the comparatively simple and efficient method of transverse control by sliding surfaces, applied here for the first time.

The Frame.—The framework is largely a combination of numerous king-post trusses with spruce compression members and wire tension members. The framework is open throughout, thus enabling quick inspection and easy repairs. The chassis at the center is mainly of steel tubing.

The Supporting Plane.—The main supporting plane at a 5-deg. dihedral angle consists of two main beams across which are placed spruce ribs. The surface is made of Baldwin vulcanized silk, of jet black color, tacked to the top of the ribs and laced to the frame. The curvature of the surface is slight and is designed for high speed. The spread is 31 feet, the depth 6 feet, and the surface area 186 square feet.

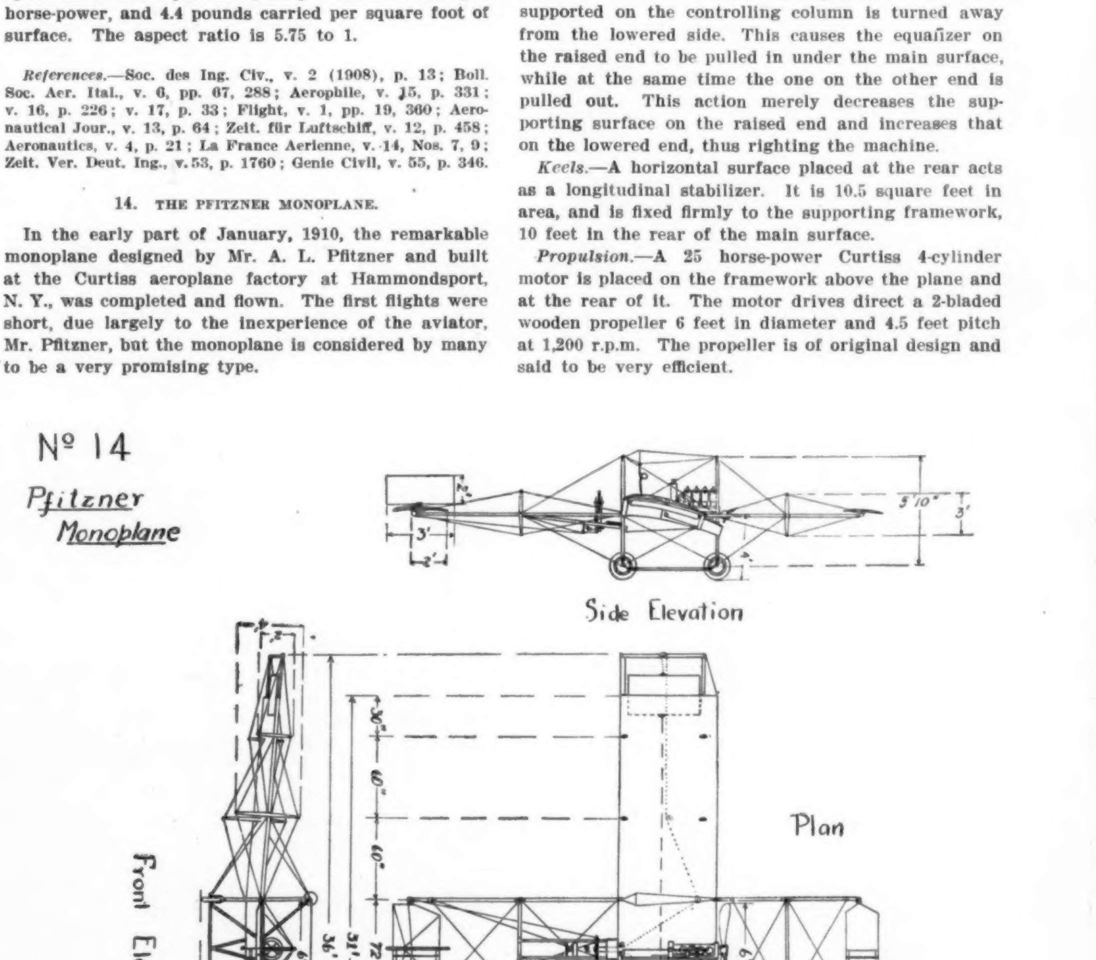
The Direction Rudder.—The direction rudder, a rectangular surface, is placed at the front and has an area of 6 square feet. It is operated by wires leading to the bracket underneath the controlling column. By turning this column to either side the aeroplane turns to that side.

The Elevation Rudder.—The elevation rudder consists of a single surface 17 square feet in area placed also at the front. It is operated by wires leading to the lever at the side of the controlling column. By moving this column forward or backward, the elevation rudder is caused to turn down and turn up respectively.

Transverse Control.—The framework of the main surface is carried out 30 inches on either end of the surface, and affords a place for the rail upon which the auxiliary sliding surfaces move. These sliding surfaces, or "equalizers" are each 12½ square feet in area, and when normal project 15 inches beyond the end of the surface on either side. They are connected by a wire to each other, and a long cable running to each end through a pulley connects them to the steering wheel. The control is then as follows: If the right end of the aeroplane is tipped down the wheel supported on the controlling column is turned away from the lowered side. This causes the equalizer on the raised end to be pulled in under the main surface, while at the same time the one on the other end is pulled out. This action merely decreases the supporting surface on the raised end and increases that on the lowered end, thus righting the machine.

Keels.—A horizontal surface placed at the rear acts as a longitudinal stabilizer. It is 10.5 square feet in area, and is fixed firmly to the supporting framework, 10 feet in the rear of the main surface.

Propulsion.—A 25 horse-power Curtiss 4-cylinder motor is placed on the framework above the plane and at the rear of it. The motor drives direct a 2-bladed wooden propeller 6 feet in diameter and 4.5 feet pitch at 1,200 r.p.m. The propeller is of original design and said to be very efficient.



The Seat for the aviator is placed out in front of the main plane and directly in the center line.

The Mounting is on four small rubber-tired wheels, placed at the lower ends of the four main vertical posts of the chassis. The wheels are not mounted on springs. They are spaced by steel tubing and are fitted with brakes.

The total weight in flight is from 560 to 600 pounds. The speed is estimated at 42 miles per hour; 24 pounds are lifted per horse-power, and 3.2 pounds carried per square foot of surface. The aspect ratio is 5.17 to 1.

References.—Aeronautics, v. 6, p. 53, February, 1910; v. 6, p. 82, March, 1910.

(To be continued.)

HIGH-FREQUENCY MEASUREMENTS.

APPARATUS FOR DETERMINATION OF CONSTANTS.

THE periods and wave-lengths of the electrical circuits employed in wireless telegraphy are usually determined by measuring the maximum deflection of a galvanometer needle. Zero methods are preferred for most physical determinations, as they are generally more sensitive and exact than methods which require the actual measurement of deflections. Braun and his pupils endeavored, long ago, to apply the zero method to high-frequency measurements. In a recent issue of the Physikalische Zeitschrift, L. Kann describes an apparatus devised for the determination of the constants of oscillatory electric circuits by the zero method. Fig. 1 shows an exterior view of the apparatus.

In order to understand the principle of its operation, it must be recalled that in the case of resonance or unison of a primary and a secondary circuit (Fig. 2) there is a difference of phase, amounting to $\pi/2$, or one-quarter period, between the inducing and induced currents. In these conditions, if the primary current is represented by the formula $a = A \sin nt$, where n is the frequency, t the time, and A the amplitude, or maximum value of the primary current, the induced current may be represented by the formula $b = B \cos nt$, where B is the amplitude of the induced current, and the sum of the two currents may be represented

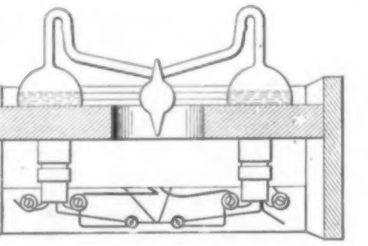


FIG. 1.

by the formula $a + b = c = C \sin (nt + p)$, where C is the amplitude of the total or resultant current and p is the difference of phase between it and the primary current. Hence $C \sin (nt + p) = A \sin nt + B \cos nt$.

A, B, C, p, and n are constants, and the equation is true for all values of t. By putting nt equal successively to 0 and to $\pi/2$, we find, $C \sin p = B$, and $C \cos p = A$. Hence $C^2 = A^2 + B^2$.

Now, the heating effect of an undulatory current is

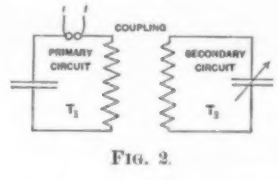


FIG. 2.

proportional to the square of its amplitude. Hence the equation $C^2 = A^2 + B^2$ expresses the fact that in the case of resonance the aggregate heating effect of the primary current and its induced current is the same, whether the two currents flow together through a coil of given resistance, R, or separately through two coils, each of resistance R.

Conversely, the equality of the heating effects proves that the two currents differ in phase by one-quarter period and, consequently, that the two circuits have exactly equal periods of oscillation.

In the apparatus here described, the heating effects are produced, not by the currents of the two open condenser circuits which are to be compared, but by currents which are induced by these in two closed aperiodic circuits, and which are proportional respectively to the amplitudes of the currents of the primary and secondary condenser circuits.

Thus, the current J_1 of the primary condenser circuit (Fig. 3) which induces the current J_2 in the secondary condenser circuit, simultaneously induces the current i_1 in the closed circuit I_1 and the current J_2 induces the current i_2 in the closed circuit I_2.

The closed circuits I_1 and I_2 are connected with four similar heating coils in such a manner that the first coil receives the sum of the currents, $i_1 + i_2$, the second coil the current i_1, and the third coil the current i_2, while no current flows through the fourth coil, which is added only for symmetry.

The first and fourth coils are inclosed in one bulb K_1, the second and third coils in the other bulb K_2, of a differential air thermometer. The bulbs are connected by the capillary tube k, which has at its ends two small bulbs SS, which are connected by a tube provided with a stop-cock H, for the purpose of equalizing the air pressure in the two large bulbs. The bent capillary tube contains a short thread of mercury or other liquid a, which serves as an index, and stands exactly in the middle of the tube when the temperature of the air in the two bulbs is the same. As one bulb is heated by the currents i_1 and i_2, acting separately, and the other by their sum, $i_1 + i_2$, flowing through a single coil, the equality of temperature indicates that the square of the sum of the amplitudes of these currents is equal to the sum of their squares. A similar relation exists between the amplitudes of the currents in the two condenser circuits and, therefore, these circuits have the same period of oscillation.

In using the apparatus, the circuit of which the period is to be measured is made the primary circuit. The secondary circuit is provided with an adjustable condenser, and its period is known for every value of

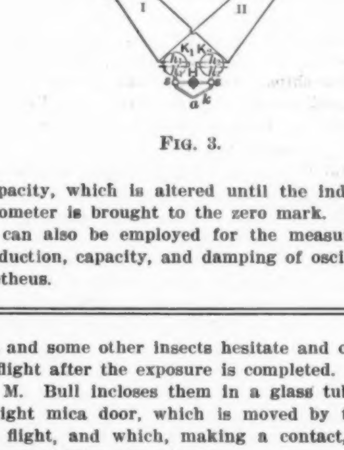


FIG. 3.

its capacity, which is altered until the index of the thermometer is brought to the zero mark. The apparatus can also be employed for the measurement of self-induction, capacity, and damping of oscillations.—Prometheus.

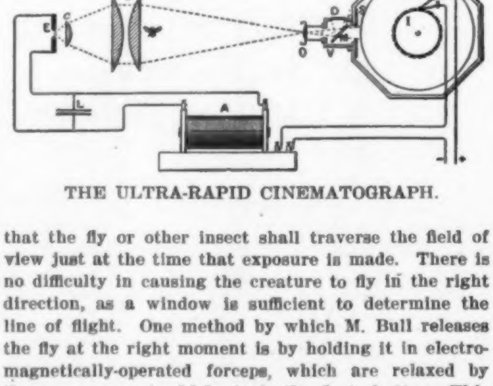
THE ULTRA-RAPID CINEMATOGRAPH.

By C. V. BOYS.

A RECENT number of La Nature contains a very interesting account of the latest work of the Marey Institute. By means of the new instrument, the ultra-rapid cinematograph invented by M. Bull, sharp stereoscopic cinematograph views may be obtained of such extremely rapid movements as, for instance, the flight of a fly or the breaking of a soap bubble. With the ordinary cinematograph the photographic film moves discontinuously, being arrested at the moment of each exposure. While this is simple enough at moderate speeds, it would be quite impossible where the exposures are at the rate of 2,000 a second, and the mean speed of the film 4,000 centimeters (1,575 inches) a second. These are the figures that are necessary for the study of insect flight, and these are attained in the new instrument. With such a speed the movement of the film must be continuous, and a sharp image is possible only if the exposure does not exceed 1/400,000 second, and for this the electric spark gives a light of sufficiently short duration.

The apparatus is shown diagrammatically in the figure. R is a wheel 34.5 centimeters (13.6 inches) in diameter, which may be turned at a high speed by means of an electric motor. It carries two long strips of photographic film to receive the stereoscopic images. On the same axis, but outside the octagonal light-proof case, is fastened an interrupter, I, of fifty-four strips of copper, which serve to make and break the primary circuit of an induction coil fifty-four times every turn, or 2,000 times a second. The secondary of the induction coil is connected with a pair of spark-gaps, E, arranged in series, the electrodes being of magnesium to increase the light. The arrangement of the two gaps and their relation to the optical system are shown in plan (left for right) in the upper left-hand corner of the figure. A condenser, L, is connected to the wires leading to the spark-gaps. The optical system is made clear by the figure, but the lenses are made of quartz and Iceland spar instead of glass, so as to be transparent to the actinic rays of short wave-length for which glass is opaque. A mirror, M, throws the pair of images on a ground-glass screen, D, or, on being turned up out of the way, it leaves a clear passage for them to be formed on the films. In order to prevent the photographs from being spoiled by multiple exposure, two shutters of thin steel, actuated by springs, are released electromagnetically one after the other, the interval being the duration of one turn of the wheel.

The movements photographed are determined as to time by fine wire prolongations of the prongs of a tuning-fork of 50 waves a second, which are photographed at each successive exposure, and as to distance by a divided glass scale, which equally appears in every picture. It is, of course, necessary to insure



THE ULTRA-RAPID CINEMATOGRAPH.

that the fly or other insect shall traverse the field of view just at the time that exposure is made. There is no difficulty in causing the creature to fly in the right direction, as a window is sufficient to determine the line of flight. One method by which M. Bull releases the fly at the right moment is by holding it in electro-magnetically-operated forceps, which are relaxed by the same current which starts the first shutter. This works well enough with ordinary flies, but hymenoptera and some other insects hesitate and only make their flight after the exposure is completed. For such cases, M. Bull incloses them in a glass tube with a very light mica door, which is moved by the insect in its flight, and which, making a contact, sets the shutter mechanism in action.

In order to study the movements represented on the films, which in nature are far too rapid to be followed by the eye, it is merely necessary to pass them through an ordinary cinematograph, making some fifteen exposures a second instead of the 1,500 or 2,000 a second employed in taking the photograph, and then the movement, 100 or more times as slow, will be seen, and in many cases easily followed. Where a still greater slowing is required, M. Bull arranges to make the film appear stationary for a much larger proportion of the whole interval than is usual, and then only two or three views a second are sufficient to give an apparently continuous movement.—Nature.

E. Stephan describes in Beton u. Eisen an investigation of the cause of failure of the concrete covering of some sewage tanks. Although in the sewage-water a strong smell of hydrogen sulphide was perceptible, no trace of this compound could be detected in the atmosphere of the sewage tanks, which was also free from sulphur trioxide, but contained carbon dioxide. The outer layers of the defective concrete were so soft that they could readily be removed by a powerful jet of water; the firm concrete beneath was of a brownish tint. A considerable portion of the lime in the decomposed concrete was in the form of calcium sulphate, but small quantities of calcium hydrogen sulphide were also present, indicating that the decomposition was caused by hydrogen sulphide, the calcium sulphide formed at first becoming ultimately converted into sulphate. Stephan recommends the application of a coating of tar to the concrete after the latter has hardened to some extent and is thoroughly dry.

BY CABLE TO THE ARCTIC.

THE REALIZATION OF A DREAM.

BY GEORGE E. WALSH.

To connect Alaska with the rest of the world by cable and telegraph was a dream of our government which a few years ago seemed almost impossible of achievement. But to our Signal Corps men, under Gen. A. W. Greely, chief of the service, and ranking brigadier-general in the army, this stupendous undertaking was referred and immediately pronounced feasible and possible. With him he associated such veteran co-workers as Col. James Allen, of the Signal Corps service, to assume charge of the cable-laying work along the Alaskan coast; Capt. Charles Stuart Wallace, brother of the recently appointed chief engineer of the Panama Canal, to take command of the cable-laying ship "Burnside;" Mr. David Lynch, as expert cable operator and chief electrician; and Mr. Henry Winter, to take personal charge of cable engineering.

To these men we owe the successful building of the new cable and overland telegraph system to Nome, under the Arctic Circle.

Almost insurmountable difficulties were found on land and sea, and for several years the signal corps men struggled against climatic and other dangers until their resources and nerves were taxed to the utmost. To understand some of their troubles and problems would help us to appreciate the achievements of the Signal Corps men at their proper worth.

The final completion of the all-American Alaskan cable is a triumph in many ways, but particularly so as an indication of what a small body of plucky individuals can do in a short time.

It must be remembered that prior to the Spanish-American war the United States had no cable whatever, and the Signal Corps men had never had the opportunity to gain any experience in handling cable ships or grappling machines. All of the world's cables up to that time were handled by English, German, or French ships and workmen.

When the war with Spain broke out, the navy and army immediately felt the need of cable-cutting and cable-laying ships. The converted cruiser "Yale" one day captured the Spanish merchant ship "Rita" off the coast of Cuba. This minor incident of the war may have left no impression upon the minds of readers of the papers; but the "Rita" was destined to figure as a most important factor in the future triumphs of peace.

She was remodeled as a cable ship, and rechristened the "Burnside." It is this ship which has achieved such lasting glory for the Signal Corps service. After serving as a cable ship off the coast of Cuba until the war ended, she sailed for the Philippine Islands. It was imperative that cables should be laid along the different islands of our new possessions in the Far East, and the "Burnside" proceeded to reel out hundreds of miles of cable.

Over 2,000 miles of submarine cables were laid around Manila and the adjacent towns of the coast. The "Burnside" was then brought home and finally commissioned to lay the Alaskan cable. Altogether she has laid over 1,500 miles of cable. It is estimated that at the end of 1904 the United States government will have in operation over 3,500 miles of submarine cables, nearly one-half of which were laid by the old Spanish merchant ship "Rita," or as she is now called, "Burnside." This makes our government the second in the number of miles of submarine wire laid and owned, exceeding the possessions of Great Britain and Ireland by over 800 miles, and about 1,500 miles less than the number owned by France. And this has all been accomplished within the few years elapsing since the Spanish-American war, and the "Burnside" has the glory of doing most of the work. Surely the triumphs of peace sometimes select strange agencies for the accomplishment of ends!

The new all-American Alaskan cable was laid by the "Burnside" up the coast from Seattle to Skagway near the head of Lynn Canal. Branches were run to Sitka, the nominal capital of Alaska, and to Juneau, Haines Mission, and two other places along the coast.

The Alaskan coast in winter is wild and rough, with the seas filled with great cakes of ice, and even in summer dangerous icebergs float down from the north. The "Burnside" encountered great difficulties in reeling out the cable. In rounding Vancouver Island near the Straits of Juan de Fuca, the water was 1,600 fathoms deep, or about 10,000 feet. It was a delicate and intricate work to lay the cable at this point without breaking it. Moreover, it was necessary to buoy the end of the cable in the middle of the straits while the cable-ship returned to Seattle to connect the other end with the shore.

Then in the middle of the winter operations had to be suspended. The weather was too rough, and the seas too boisterous for work. Meanwhile, the services of the "Burnside" were needed elsewhere. A cable laid among the Philippine Islands a year before was out of order, and the plucky little ship had to cross the Pacific to repair it.

When she returned from this long trip, she turned her attention once more to the Alaskan cable. Beginning north, she worked south, picking up the end of the cable where she had left it buoyed in the middle of the straits. When her work was finished, the cable was found to work perfectly, and Washington began to talk with the cities of Nome, Juneau, Sitka and Dawson.

But to make the cable an all-American one it was necessary to lay another short one from Skagway to Valdez. Without this shorter cable, the Canadian lines extending across White Pass and down the Yukon to Dawson had to be used. The Washington government wished to have an all-American cable and telegraph line to our most northerly possessions, and so the "Burnside" proceeded to finish the last gap in the system.

Meanwhile, strenuous work on land was being performed by the Signal Corps men who were commissioned to string wires across country to connect with the cable at different points. The difficulties of this work were in many respects greater than those encountered on the seas. Here was a wild, uninhabited country, thousands of miles in extent, swept by blizzards in winter, and soft and marshy in summer, across which wires had to be stretched strong enough to resist the storms of winter and withstand the floods and freshets of the short summers. The workmen had to carry their supplies of provisions with them, working weeks and months hundreds of miles away from any base of supplies. From Eagle to Valdez they followed the old government trail 400 miles in length; but down the Tanana they broke entirely new, unexplored regions, and had to string the wires over snow a dozen feet deep, and then return in summer to erect the poles. From Yukon to St. Michael they passed through 800 miles of the most inhospitable country, struggling against blizzards and storms that threatened to destroy them. Up from St. Michael through the Tanana, they worked in the heat of a summer that seemed greater than any that ever visited the tropics, and then to make matters worse a forest fire broke out in their rear and swept hundreds of miles of newly-erected poles away. Back they had to go and toilsomely reconstruct the line.

Farther up in the frozen North they penetrated, crossing ice-fields and snow-capped mountains until the city of Nome was almost within sight. They stood on the shores of Norton Sound. It was only a few days' journey to the end of their mission. But how could the body of water ahead be crossed? Heretofore couriers carried the mails from St. Michael to Nome across the ice in winter and by boat in summer. It was this distance of 115 miles to bridge that offered the hardest problem of the whole route.

A cable across the sound was suggested. But for six months in the year the water would be frozen solid, and when the cold winter came the cable would be snapped like straw. The only possible solution was by wireless telegraphy. So, far up there under the Arctic Circle, a wireless telegraph station was established. Long timbers were transported up the coast and across the country for masts to support the wires at the stations. Great quantities of electrical apparatus were carried to the station, and then the experiment proved a failure. The impulses across the sound were so slight that it seemed as if wireless telegraphy in that great, cold northern country had lost its power. Other apparatus was shipped, and in time the long line to Nome was completed by the successful working of this last stretch.

With the all-American Alaskan line completed the question of maintaining it now comes up for solution. In the winter season the awful blizzards and snow storms destroy the telegraph poles and snap the wires so that interruptions are common. Relay stations have to be established at frequent intervals, and repair crews are ready to hunt up troubles with the wire at any moment. These repair crews are provided with dog-trains or reindeer sleds, and on these they cross miles of frozen country in the worst sort of Arctic weather.

In the spring and summer the snow melts rapidly on the sides of the mountains, and the swollen rivers and streams inundate the country, washing away poles and tangling fallen wires. The repair crews must then in their summer outfits struggle against water, marsh, mosquitoes, and millions of other annoying insects. Often the ground in the valleys is so soft that the crew cannot cross to reach the poles.

Then again, upon the bleak mountain sides, and in the passes, the wind attains a velocity frequently of sixty miles an hour, and trees and telegraph poles are swept down like chaff. How to protect the line from such storms is another problem.

In addressing the British Association for the Advancement of Science, on the subject of photo-electric fatigue, Mr. H. Stanley Allen, M.A., D.Sc., stated that the observation of Hertz in 1887 that the electric spark passes more readily when the spark gap is illuminated by ultra-violet light led to the discovery by Hallwachs of the photo-electric current. A negatively-charged body often loses its charge rapidly when exposed to light, especially to ultra-violet light. The discharge is due to the emission of negative electrons from the illuminated surface. The photo-electric activity of a freshly-polished metal surface diminishes with the time, falling off rapidly at first, more slowly later on. This is known as the "fatigue" of the Hallwachs effect. In the early literature of the subject the fatigue was attributed to the direct action of the light, but Hallwachs showed in 1904 that fatigue proceeds in complete darkness, so that light cannot be the primary cause of the change. This result has been questioned, but is now confirmed by the experiments of Bergwitz, Dember, Ullman, and Allen. Light can, however, set up secondary actions tending to accelerate or retard fatigue. Hallwachs has shown that at ordinary pressures fatigue is more rapid in a large vessel than in a small one. This also was called in question by Aigner but is confirmed by Ullmann and by Allen. The fatigue is practically independent of the electrical condition of the plate. This was shown by v. Schweidler, and has received confirmation in the researches of Hallwachs, Sadzewicz, and Allen. Experiments in a vacuum have led to contradictory results. Lenard and Ladenburg found marked fatigue in certain cases, while for the alkali metals, first investigated by Elster and Geitel, several observers conclude that there is no true fatigue. Recent experiments by Millikan and Winchester show no fatigue with clean unpolished metal surfaces in a very high vacuum. To explain the fatigue found by other investigators we must take into account the mode of preparation of the surface (Ladenburg's plates were polished with emery and oil), the difficulty of removing air-films from the surface, and the possibility of changes in the gas pressure. Various theories have been advanced as to the nature of the change accompanying photo-electric fatigue: (1) A chemical change, such as oxidation of the surface. (2) A physical change of the metal itself, as, for example, a roughening of the surface. (3) An electrical change in the formation of an electrical double layer (Lenard.) (4) A disintegration of the metal, due to the expulsion of electrons by light (Ramsay and Spencer). (5) A change in the surface-film of gas or in the gas occluded in the metal (Hallwachs.) Hallwachs has shown from the photo-electric behavior of copper and its oxides that oxidation cannot be the cause of fatigue, and the fact that fatigue is less in a small vessel may be interpreted by attributing it to some substance (e. g., ozone, water vapor) present in small quantities in the surrounding atmosphere. The results recorded lead to the view that the main cause of fatigue is to be found in the condition of the gaseous layer at the surface of the plate.

Engineers in the employment of the North British Railway are at present engaged in the neighborhood of the new naval base at Rosyth in surveying ground which has been acquired for the purpose of constructing a railway, which it is intended should be run from a point on the Charleston line to Kinniny Point, the site of the arsenal which is to be established by the Admiralty on the lands of Crombie, about four miles to the west of Dunfermline. The new naval base will be a source of considerable revenue to the company, particularly during the next few years, and the directors are understood to be giving the development of their system in this district full consideration.

GERMAN AIRSHIP SHEDS.

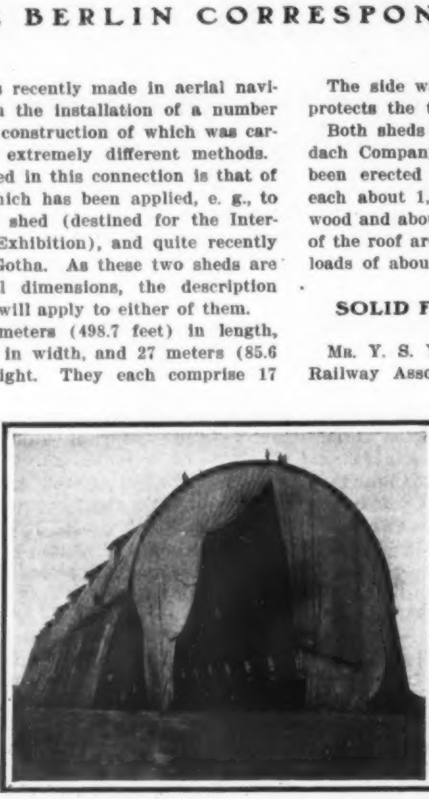
A NEW STYLE OF ARCHITECTURE.

BY THE BERLIN CORRESPONDENT OF THE SCIENTIFIC AMERICAN.

THE powerful strides recently made in aerial navigation have resulted in the installation of a number of airship harbors, the construction of which was carried out according to extremely different methods.

The latest system used in this connection is that of timber construction, which has been applied, e. g., to the Düsseldorf airship shed (destined for the International Aeronautical Exhibition), and quite recently to the one erected at Gotha. As these two sheds are of practically identical dimensions, the description given in the following will apply to either of them.

The sheds are 152 meters (498.7 feet) in length, 35 meters (114.8 feet) in width, and 27 meters (85.6 feet) in maximum height. They each comprise 17 circular binders, which are excellently adapted to the round shape of airships. These binders rest on wooden framework girders 13 meters (42.65 feet) in height, which form their abutments so as to leave the interior entirely disengaged.



THE DÜSSELDORF AIRSHIP SHED COMPLETED, AND FRONT END CURTAIN SHOWN DRAWN ASIDE.

THE GOTHA AIRSHIP SHED. THE CURTAIN LOCKED AND FIRMLY MOORED AT BOTTOM.

THE DÜSSELDORF AIRSHIP SHED OF TIMBER CONSTRUCTION IN COURSE OF ERECTION.

GERMAN AIRSHIP SHEDS.

The walls and the roof of the shed are lined with planks. Side windows as well as dormer windows, skylights, and several ridge turrets provide ample lighting and ventilation. The roof is lined with ruberoid.

A big sailcloth curtain, reinforced with several tightened cables, serves to lock the shed at its front, and it is moored at the bottom so as to secure it in absolute safety. The rear end of the structure is closed by a framework wall lined with planks. In the case of the Gotha airship shed, sliding doors will probably be eventually provided.

The foundation of the shed consists of concrete pillars resting upon substantial concrete bases. The floor is likewise of concrete.

The side walls are coated with carbolineum, which protects the timber against atmospheric influences.

Both sheds have been constructed by the Stephansdach Company at Düsseldorf, the Gotha shed having been erected in about four months. They contain each about 1,000 cubic meters (35,314 cubic feet) of wood and about 25 tons of iron. The suspended binders of the roof are of sufficient strength to deal with crane loads of about 20 tons.

SOLID FORGED AND ROLLED STEEL CAR WHEELS.

MR. Y. S. YATNELL read a paper before the Street Railway Association of the State of New York on the methods employed by the Carnegie Steel Company in the manufacture of Schoen steel wheels. Ingots of the proper composition being selected, they are heated and rolled in the slab form, about 26 inches wide by 4¾ inches thick, the reduction being about 6 to 1. The first operation in the wheel plant is heating the slab. The slab after heating is forged in a 7,000-ton hydraulic press. This forging machine carries in addition to the top forging die a heavy circular knife or shear, and, after the first forging operation, the blank is sheared by the same machine to circular form. After the blank has been reheated, it is subjected to the second forging operation in a 5,000-ton capacity hydraulic press. A ring is slipped over the hot blank, and through this ring the rim alone is given an extra forging. The result of these two successive forgings is that the metal has been pressed from the center of the slab and condensed in the rim. From the second forging press the blank passes through the punch, where the metal left in the hub by the acorn-shaped dies of the forge is removed by a specially constructed punch. This punch exerts a pressure of 750 tons. The blank again passes to another heating furnace, where it is heated uniformly, after which it is rolled in a special rolling-mill, where the rim of the wheel receives a thorough working or rolling; a mandrel is placed through the hub, and the wheel is supported in this manner during the rolling operation. There are five rolls, all bearing on the wheel at the same time. The two web rolls, which are power-driven, have bearing surface extending from directly under the rim to within 6 inches of the hub. The back roll, formed to fit the tread and flange, is on the same horizontal plane as the web rolls and directly in line with the center of the wheel; the two side rolls bearing on the edge of the rim work by friction. All the rolls are adjustable, and during the rolling operation the back roll is forced toward the web rolls, compressing the metal in the rim to the required density, and can be varied according to the amount of rolling and the temperature at which the metal is finished. The web of the wheel, as it comes from the rolls, is flat and at right angles to the tread. The wheel is taken from the rolling mill at about a cherry red and is given the proper amount of cooling or dishing. Under the same press the wheel is made truly round by compressing its circumference in a die composed of segments of a circle.

During the year 1909, 3,748 miles of new track were built in the United States. This is an increase of five hundred and thirty-four miles over the year 1908, which was the year of least new construction since 1897, when 2,109 miles were built.

A SMELTING CHARGE CALCULATOR.

BALLING'S NEW INSTRUMENT.

BY THE PARIS CORRESPONDENT OF THE SCIENTIFIC AMERICAN.

PROF. BALLING of Pribram, Bohemia, simplified metallurgical calculations by the introduction of a series of factors and their reciprocals, these factors being known as Balling's tables, and are universally used. They relate to the parts by weight of the bases to unity of weight of silica (or acid) in the various silicates, i. e., mono or singulo silicates, bisilicates,

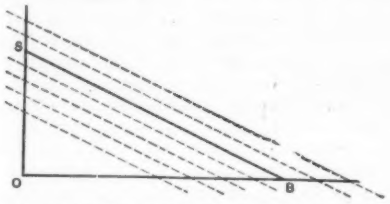


FIG. 1.—DIAGRAM OF TRIANGLE IN CALCULATING WEIGHTS OF BASE AND SILICA.

and sesquisilicates, of the different bases, such as lime, magnesia, alumina, ferrus oxide, and manganous oxide, etc., and the reciprocals of these factors relate to the parts by weight of silica to unity of weight of each of the bases.

Briefly described, the application is as follows:

When it is desired to ascertain the quantity of silica which will be utilized by each quantity of the various bases in a given charge of ore, in the formation of, say, bisilicates, the weight of each base is multiplied by the bisilicate reciprocal corresponding to the base, and the product is the weight of silica which will be utilized.

Should the sum of these quantities of silica be less than the total weight of silica in the ore charge, then the weight of silica which represents the excess should be multiplied by the bisilicate factor corresponding, say, to the base lime, this will give the weight of additional base required.

In order to eliminate the possibility of error in these simple calculations, Prof. Balling devised a graphic system of right angled triangles, in which the ratio between the two sides containing the right angle corresponds with the ratio of the weights of base and silica in any particular silicate. Thus if a horizontal line be drawn representing by its length the weight of base, and a perpendicular at one of its extremities be drawn, representing by its length, on the same scale, the weight of silica required to form the particular silicate, and the hypothenuse be also drawn, then for that particular silicate, all lines drawn parallel to the hypothenuse will cut off from the horizontal and vertical sides of the triangle, lengths corresponding to amounts of base and silica for any weight of either.

In the triangle *OBS* let the horizontal side *OB* represent the base and the vertical side *OS* represent the silica, produce the sides *OB* and *OS* in the directions *B* and *S*. Then all lines drawn parallel to *BS* will cut off from *OB* and *OS* proportional quantities of base and silica.

$$\text{Also } \frac{OB}{OS} = \text{factor and } \frac{OS}{OB} = \text{reciprocal.}$$

The angle *OBS* changes with the silicate degree; it also is different for each base.

Later, Mr. Taylor devised a system of triangles on a common horizontal base divided in a convenient manner, and furnished with a traveling vertical scale. It took the form of a small drawing board and a tee square, shown in Fig. 2. The blade of the square on one edge was divided to form the vertical scale, which could be moved to any position so as to measure the vertical distance between the base line scale and the hypothenuse of any of the triangles.

Marshall's smelting charge calculator is a further development of the graphic method, and its advantages over the other systems, including the tables, are several, and sufficiently obvious.

This system has been extended to include in the form of scales, all that is necessary for the various calculations relating to the matte in copper smelting, tedious detail work of the calculations, more opportunity is given to concentrate the mind on the principles involved throughout the various operations.

In the accompanying illustration (Fig. 3) the outermost divided circle represents parts by weight of bases, matte, etc. The inner divided circles represent the corresponding weights of silica to form mono and

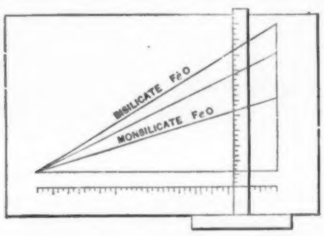


FIG. 2.—DIAGRAM OF DEVICE FOR MEASURING VERTICAL DISTANCE BETWEEN BASE LINE SCALE AND HYPOTHENUSE.

sesqui silicates, with the bases, lime, magnesia, ferrous oxide, and alumina; also they indicate the iron, copper, sub-sulphide, and sulphur in the matte, etc. On the reverse side (Fig. 4) there is a very practical and useful circular slide rule, with an equivalent length

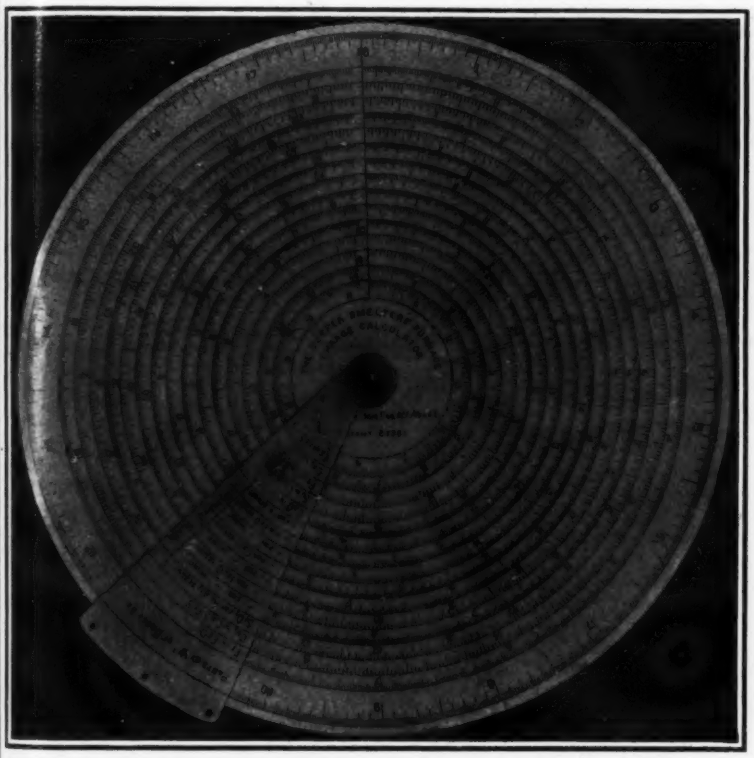


FIG. 3.—PORTABLE INSTRUMENT FOR MAKING EVERY CALCULATION IN CONNECTION WITH A SMELTING CHARGE.

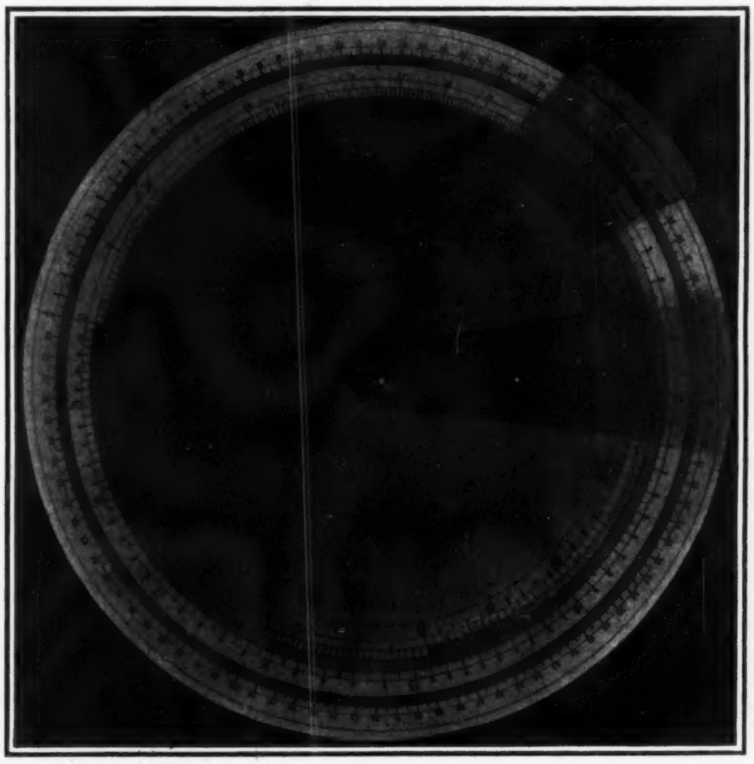


FIG. 4.—REVERSE SIDE OF INSTRUMENT. IT IMMEDIATELY CALCULATES FROM ASSAY PERCENTAGES THE AMOUNT OF EACH ORE CONSTITUENT.

A SMELTING CHARGE CALCULATOR.

as well as the scales for the calculation of the silicates.

The circular form adopted, makes possible a portable instrument capable of giving an accurate reading, and very convenient to handle.

The combination of the circular slide rule with the metallurgical scales, provides an instrument which enables every calculation connected with a smelting charge to be made direct from the percentages given by the assay of the ore.

Thus the advantage of the use of the "calculator" over the use of the tables is that the tedium of the calculations is avoided and much time saved, as the results are instantly obtained, while the possibility of error is eliminated.

The advantage of the "calculator" over the other devices is, that it is more complete, is portable and very convenient to handle, and the combination of the circular slide rule enables any required calculation to be made with the greatest rapidity, in fact, instantly, and with absolute accuracy.

By the use of a table of subsidiary factors which has been prepared for the purpose, the calculation of silicates of any formula, can be made.

The study and analysis of any silicate, or matte combination, is rendered rapid and easy by the use of this calculator, familiarity with which can be acquired in a few minutes. It has, besides a high educational value, since, by the elimination of the

of about 23 inches by means of which the amount of each constituent of the ore is immediately calculated from the assay percentages by a simple movement of the revolving disk.

In the Zeitschrift für Elektrochemie, Herrn. Bergius and Krassa state that they have investigated the conditions under which iron pipes embedded in the ground are corroded by stray currents from tramways operated by alternating current and the three-conductor system. For the purpose of facilitating corrosion they employed town water in place of earth as the embedding material. The use of this medium also increased the effect of diffusion, and precluded the possibility of the iron becoming passive through the alkalinity of the surrounding water. Experiments with alternating current of 15 and 50 periods showed that cast iron was not corroded. In the case of continuous current, the direction of which was changed at intervals of one to four hours, the corrosion was not less than when the current was not reversed at all. At the same time the corrosion was intensified by purely chemical action, which, however, depended largely on the surface conditions of the metal, the casting skin on unworked pipes affording protection at first against electrolytic and chemical corrosion, though this property was soon dissipated by powerful anodic polarization and by chemical influences.

THE FERTILITY OF THE SOIL.*

CHEMISTRY AND FARMING.

BY A. D. HALL.

If we go back to the seventeenth century, which we may take as the beginning of organized science, we shall find that men were concerned with two aspects of the question—how the plant itself gains its increase in size, and, secondly, what the soil does toward supplying the material constituting the plant. The first experiment we have recorded is that of Van Helmont, who placed 200 pounds of dried earth in a tub, and planted therein a willow tree weighing 5 pounds. After five years the willow tree weighed 169 pounds 3 ounces, whereas the soil when redried had lost but 2 ounces, though the surface had been carefully protected meantime with a cover of tin. Van Helmont concluded that he had demonstrated a transformation of water into the material of the tree. Boyle repeated these experiments, growing pumpkins and cucumbers in weighed earth and obtaining similar results, except when his gardener lost the figures, an experience that has been repeated. Boyle also distilled his pumpkins, etc., and obtained therefrom various tars and oils, charcoal and ash, from which he concluded that a real transmutation had been effected, "that salt, spirit, earth, and even oil (though that he thought of all bodies the most opposite to water) may be produced out of water."

There were not, however, wanting among Boyle's contemporaries men who pointed out that spring water used for the growing plants in these experiments contained abundance of dissolved material, but in the state of chemistry at that time the discussion as to the origin of the carbonaceous material in the plant could only be verbal. Boyle himself does not appear to have given any consideration to the part played by the soil in the nutrition of plants, but among his contemporaries experiment was not lacking. Some instinct seems to have led them to regard niter as one of the sources of fertility, and we find that Sir Kenelm Digby, at Gresham College in 1660, at a meeting of the Society for Promoting Philosophical Knowledge by Experiment, in a lecture on the vegetation of plants, describes an experiment in which he watered young barley plants with a weak solution of niter and found how their growth was promoted thereby; and John Mayow, that brilliant Oxford man whose early death cost so much to the young science of chemistry, went even further, for, after discussing the growth of niter in soils, he pointed out that it must be this salt which feeds the plant, because none is to be extracted from soils in which plants are growing. So general has this association of niter with the fertility of soils become that in 1675 John Evelyn writes: "I firmly believe that where saltpeter can be obtained in plenty we should not need to find other composts to ameliorate our ground;" and Henshaw, of University College, one of the first members of the Royal Society, also writes about saltpeter: "I am convinced indeed that the salt which is found in vegetables and animals is but the niter which is so universally diffused through all the elements (and must therefore make the chief ingredient in their nutriment, and by consequence all their generation), a little altered from its first complexion."

But these promising beginnings of the theory of plant nutrition came to no fruition; the Oxford movement in the seventeenth century was but the false dawn of science. At its close the human mind, which had looked out of doors for some relief from the fierce religious controversy with which it had been so long engrossed, turned indoors again and went to sleep for another century. Mayow's work was forgotten, and it was not until Priestley and Lavoisier, De Saussure, and others, about the beginning of the nineteenth century, arrived at a sound idea of what the air is and does that it became possible to build afresh a sound theory of the nutrition of the plant. At this time the attention of those who thought about the soil was chiefly fixed upon the humus. It was obvious that any rich soils, such as old gardens and the valuable alluvial lands, contained large quantities of organic matter, and it became somewhat natural to associate the excellence of these fat, unctuous soils with the organic matter they contained. It was recognized that the main part of a plant consisted of carbon, so that the deduction seemed obvious that the soils rich in carbon yielded those fatty, oily substances which we now call humus to the plant, and that their richness depended upon how much of such material they had at their disposal. But by about 1840 it had been definitely settled what the plant is composed of and whence it derives its nutriment—the carbon compounds which constitute nine-tenths of the dry weight from the air, the nitrogen, and the ash from the soil. Little as he had contributed to the discovery, Liebig's brilliant expositions and the weight of his authority had driven this broad theory of plant nutrition home to men's minds; a science of agricultural chemistry had been founded, and such questions as the functions of the soil with regard to the plant could be studied with some prospect of success. By this time also methods of analysis had been so far improved that some quantitative idea could be obtained as to what is present in soil and plant, and, naturally enough, the first theory to be framed was that the soil's fertility was determined by its content of those materials which are taken from it by the crop. As the supply of air from which the plant derives its carbonaceous substance is unlimited, the extent of growth would seem to depend upon the supply available of the other constituents which have to be provided by the soil. It was Daubeny, professor of botany and rural economy at Oxford, and the real founder of a science of agriculture in this country, who first pointed out the enormous difference between the amount of plant food in the soil and that taken out by the crop. In a paper published in the Philosophical Transactions in 1845, being the Bakerian lecture for that year, Daubeny described a long series of experiments that he had carried out in the botanic garden, some grown continuously on the same plot and others in a rotation. Afterward he compared the amount of plant food removed by the crops with that remaining in the soil. Daubeny obtained the results with which we are now familiar, that any normal soil contains the material for from fifty to a hundred field crops. If, then, the growth of the plant depends upon the amount of this material it can get from the soil, why is that growth so limited, and why should it be increased by the supply of manure, which only adds a trifle to the vast stores of plant food already in the soil? For example, a turnip crop will only take away about 30 pounds per acre of phosphoric acid from a soil which may contain about 3,000 pounds an acre; yet, unless to the soil about 50 pounds of phosphoric acid in the shape of manure is added, hardly any turnips at all will be grown. Daubeny then arrived at the idea of a distinction between the active and dormant plant food in the soil. The chief stock of these materials, he concluded, was combined in the soil in some form that kept it from the plant, and only a small proportion from time to time became soluble and available for food. He took a further step and attempted to determine the proportion of the plant food which can be regarded as active. He argued that since plants only take in materials in a dissolved form, and as the great natural solvent is water percolating through the soil more or less charged with carbon dioxide, therefore in water charged with carbon dioxide he would find a solvent which would extract out of a soil just that material which can be regarded as active and available for the plant. In this way he attacked his botanic garden soils and compared the materials so dissolved with the amount taken away by his crops. The results, however, were inconclusive and did not hold out much hope that the fertility of the soil can be measured by the amount of available plant food so determined. Daubeny's paper was forgotten, but exactly the same line of argument was revived again about twenty years ago, and all over the world investigators began to try to measure the fertility of the soil by determining as "available" plant food the phosphoric acid and potash that could be extracted by some weak acid. A large number of different acids were tried, and although a dilute solution of citric acid is at present the most generally accepted solvent I am still of opinion that we shall come back to the water charged with carbon dioxide as the only solvent of its kind for which any justification can be found. Whatever solvent, however, is employed to extract from the soil its available plant food, the results fail to determine the fertility of the soil, because we are measuring but one of the factors in plant production, and that often a comparatively minor one. In fact, some investigators—Whitney and his colleagues in the American Department of Agriculture—have gone so far as to suppose that the actual amount of plant food in the soil is a matter of indifference. They argue that as a plant feeds upon the soil water, and as that soil water must be equally saturated with say, phosphoric acid, whether the soil contains 1,000 or 3,000 pounds per acre of the comparatively insoluble calcium and iron salts of phosphoric acid which occur in the soil, the plant must be under equal conditions as regards phosphoric acid, whatever the soil in which it may be grown. This argument is, however, a little more suited to controversy than to real life; it is too fiercely logical for the things themselves and depends upon various assumptions holding rigorously, whereas we have more reason to believe that they are only imperfect approximations to the truth. Still this view does merit our careful attention, because it insists that the chief factor in plant production must be the supply of water to the plant, and that soils differ from one another far more in their ability to maintain a good supply of water than in the amount of plant food they contain. Even in a climate like our own, which the text-books describe as "humid" and we are apt to call "wet," the magnitude of our crops is more often limited by want of water than by any other single factor. The same American investigators have more recently engrafted on to their theory another supposition, that the fertility of soil is often determined by excretions from the plants themselves, which thereby poison the land for a renewed growth of the same crop, though the toxin may be harmless to a different plant which follows it in the rotation. This theory had also been examined by Daubeny, and the arguments he advanced against it in 1845 are valid to this day. Schreiner has indeed isolated a number of organic substances from soils—dihydroxystearic acid and picoline-carboxylic acid were the first examples—which he claims to be the products of plant growth and toxic to the further growth of the same plants. The evidence of toxicity as determined by water-cultures requires, however, the greatest care in interpretation, and it is very doubtful how far it can be applied to soils with their great power of precipitating or otherwise putting out of action soluble substances with which they may be supplied. Moreover, there are as yet no data to show whether these so-called toxic substances are not normal products of bacterial action upon organic residues in the soil, and as such just as abundant in fertile soils rich in organic matter as in the supposed sterile soils from which they were extracted.

As then we have failed to base a theory of fertility on the plant food that we can trace in the soil by analysis let us come back to Mayow and Digby and consider again the niter in the soil, how it is formed and how renewed. Their views of the value of nitrates to the plant were justified when the systematic study of plant-nutrition began, and demonstrated that plants can only obtain their supply of the indispensable element nitrogen when it is presented in the form of a nitrate, but it was not until within the last thirty years that we obained an idea as to how the niter came to be found. The oxidation of ammonia and other organic compounds of nitrogen to the state of nitrate was one of the first actions in the soil which was proved to be brought about by bacteria, and by the work of Schloesing and Müntz, Warington and Winogradsky we learned that in all cultivated soils two groups of bacteria exist which successively oxidize ammonia to nitrites and nitrates, in which latter state the nitrogen is available for the plant. These same investigators showed that the rate at which nitrification takes place is largely dependent upon operations under the control of the farmer: the more thorough the cultivation the better the drainage and aeration, and the higher the temperature of the soil the more rapidly will the nitrates be produced. As it was then considered that the plant could only assimilate nitrogen in the form of nitrates, and as nitrogen is the prime element necessary to nutrition, it was then an easy step to regard the fertility of the soil as determined by the rate at which it would give rise to nitrates. Thus the bacteria of nitrification became regarded as a factor, and a very large factor, in fertility. This new view of the importance of the living organisms contained in the soil further explained the value of the surface soil, and demolished the fallacy which leads people instinctively to regard the good soil as lying deep and requiring to be brought to the surface by the labor of the cultivator. This confusion between mining and agriculture probably originated in the quasi-moral idea that the more work you do the better the result will be; but its application to practice with the aid of a steam plough in the days before bacteria were thought of ruined many of the clay soils of the Midlands for the next half century. Not only is the subsoil deficient in humus, which is

* Address by the Chairman of the Agricultural Sub-section of the British Association for the Advancement of Science, Sheffield, 1910.

the accumulated débris of previous applications of manure and vegetation, but the humus is the home of the bacteria which have so much to do with fertility.

The discovery of nitrification was only the first step in the elucidation of many actions in the soil depending upon bacteria—for example, the fixation of nitrogen itself. A supply of combined nitrogen in some form or other is absolutely indispensable to plants and, in their turn, to animals; yet, though we live in contact with a vast reservoir of free nitrogen gas in the shape of the atmosphere, until comparatively recently we knew of no natural process except the lightning flash which would bring such nitrogen into combination. Plants take combined nitrogen from the soil and either give it back again or pass it on to animals. The process, however, is only a cyclic one, and neither plants nor animals are able to bring in fresh material into the account. As the world must have started with all its nitrogen in the form of gas it was difficult to see how the initial stock of combined nitrogen could have arisen; for that reason many of the earlier investigators labored to demonstrate that plants themselves were capable of fixing and bringing into combination the free gas in the atmosphere. In this demonstration they failed, though they brought to light a number of facts which were impossible to explain and only became cleared up when, in 1886, Hellreigel and Wilfarth showed that certain bacteria, which exist upon the roots of leguminous plants, like clover and beans, are capable of drawing nitrogen from the atmosphere. Thus they not only feed the plant on which they live, but they actually enrich the soil for future crops by the nitrogen they leave behind in the roots and stubble of the leguminous crop. Long before this discovery experience had taught farmers the very special value of these leguminous crops; the Roman farmer was well aware of their enriching action, which is enshrined in the well-known words in the Georgics beginning: "Aut ibi flava seres," where Virgil says that the wheat grows best where before the bean, the slender vetch, or the bitter lupin had been most luxuriant. Since the discovery of the nitrogen-fixing organisms associated with leguminous plants other species have been found resident in the soil which are capable of gathering combined nitrogen without the assistance of any host plant, provided only they are supplied with carbonaceous material as a source of energy whereby to effect the combination of the nitrogen. To one of these organisms we may with some confidence attribute the accumulation of the vast stores of combined nitrogen contained in the black virgin soils of places like Manitoba and the Russian steppes. At Rothamsted we have found that the plot on the permanent wheat field which never receives any manure has been losing nitrogen at a rate which almost exactly represents the differences between the annual removal of the crop and the receipts of combined nitrogen in the rain. We can further postulate only a very small fixation of nitrogen to balance the other comparatively small losses in the drainage water or in the weeds that are removed; but on a neighboring plot which has been left waste for the last quarter of a century, so that the annual vegetation of grass and other herbage falls back into the soil, there has been an accumulation of nitrogen representing the annual fixation of nearly a hundred pounds per acre. The fixation has been possible by the azotobacter on this plot, because there alone does the soil receive a supply of carbohydrate, by the combustion in which the azotobacter obtained the energy necessary to bring the nitrogen into combination. On the unmanured plot the crop is so largely removed that the little root and stubble remaining does not provide material for much fixation.

Though numerous attempts have been made to correlate the fertility of the soil with the numbers of this or that bacterium existing therein, no general success has been attained, because probably we measure a factor which is only on occasion the determining factor in the production of the crop. Meantime our sense of the complexity of the actions going on in the soil has been sharpened by the discovery of another factor, affecting in the first place the bacterial flora in the soil, and, as a consequence, its fertility. Ever since the existence of bacteria has been recognized attempts have been made to obtain soils in a sterile condition, and observations have been from time to time recorded to the effect that soil which has been heated to the temperature of boiling water, in order to destroy any bacteria it may contain, had thereby gained greatly in fertility, as though some large addition of fertilizer had been made to it. Though these observations have been repeated in various times and places they were generally ignored, because of the difficulty of forming any explanation; a fact is not a fact until it fits into a theory. Not only is sterilization by heating thus effective, but other antiseptics, like chloroform and carbon bisulphide vapor, give rise to a similar result. For example, you will remember how the vineyards of Europe were devastated some thirty years ago by the attacks of phylloxera, and though in a general way the disease has been conquered by the introduction of a hardy American vine stock which resists the attack of the insect, in many of the finest vineyards the owners have feared to risk any possible change in the quality of the grape through the introduction of the new stock, and have resorted instead to a system of killing the parasite by injecting carbon bisulphide into the soil. An Alsatian vine-grower who had treated his vineyards by this method observed that an increase of crop followed the treatment even in cases where no attack of phylloxera was in question. Other observations of a similar character were also reported, and within the last five years the subject has received some considerable attention until the facts became established beyond question. Approximately the crop becomes doubled if the soil has been first heated to a temperature of 70 deg. to 100 deg. for two hours, while treatment for forty-eight hours with the vapor of toluene, chloroform, etc., followed by a complete volatilization of the antiseptic, brings about an increase of 30 per cent or so. Moreover, when the material so grown is analyzed, the plants are found to have taken very much larger quantities of nitrogen and other plant foods from the treated soil; hence the increase of growth must be due to large nutriment and not to mere stimulus. The explanation, however, remained in doubt until it has been recently cleared up by Drs. Russell and Hutchinson, working in the Rothamsted laboratory. In the first place, they found that the soil which had been put through the treatment was chemically characterized by an exceptional accumulation of ammonia, to an extent that would account for the increased fertility. At the same time it was found that the treatment did not effect complete sterilization of the soil, though it caused at the outset a great reduction in the numbers of bacteria present. This reduction was only temporary, for as soon as the soil was watered and left to itself the bacteria increased to a degree that is never attained under normal conditions. For example, one of the Rothamsted soils employed contains normally about seven million bacteria per gramme—a number which remains comparatively constant under ordinary conditions. Heating reduced the numbers to 400 per gramme, but four days later they had risen to six million, after which they increased to over forty million per gramme. When the soil was treated with toluene a similar variation in the number of bacteria was observed. The accumulation of ammonia in the treated soils was accounted for by this increase in the number of bacteria, because the two processes went on at about the same rate. Some rearrangements were effected also in the nature of the bacterial flora; for example, the group causing nitrification was eliminated, though no substantial change was effected in the distribution of the other types. The bacteria which remained were chiefly of the class which split up organic nitrogen compounds into ammonia, and as the nitrate-making organisms which normally transform ammonia in the soil as fast as it is produced had been killed off by the treatment, it was possible for the ammonia to accumulate. The question now remaining was, What had given this tremendous stimulus to the multiplication of the ammonia-making bacteria? and by various steps, which need not here be enumerated, the two investigators reached the conclusion that the cause was not to be sought in any stimulus supplied by the heating process, but that the normal soil contained some negative factor which limited the multiplication of the bacteria therein. Examination along these lines then showed that all soils contain unsuspected groups of large organisms of the protozoa class, which feed upon living bacteria. These are killed off by heating or treatment by antiseptics, and on their removal the bacteria, which partially escape the treatment and are now relieved from attack, increase to the enormous degree that we have specified. According to this theory the fertility of a soil containing a given store of nitrogen compounds is limited by the rate at which these nitrogen compounds can be converted into ammonia, which, in its turn, depends upon the number of bacteria present effecting the change, and these numbers are kept down by the larger organisms preying upon the bacteria. The larger organisms can be removed by suitable treatment, whereupon a new level of ammonia-production, and therefore of fertility, is rapidly attained. Curiously enough one of the most striking of the larger organisms is an amœba akin to the white corpuscles of the blood—the phagocytes, which, according to Metchnikoff's theory, preserve us from fever and inflammation by devouring such intrusive bacteria as find entrance in the blood. The two cases are, however, reversed; in the blood the bacteria are deadly, and the amœba therefore beneficial, whereas in the soil the bacteria are indispensable and the amœba become noxious beasts of prey.

Since the publication of these views of the functions of protozoa in the soil confirmatory evidence has been derived from various sources. For example, men who grow cucumbers, tomatoes, and other plants under glass are accustomed to make up extremely rich soils for the intensive culture they practise, but, despite the enormous amount of manure they employ, they find it impossible to use the same soil for more than two years. Then they are compelled to introduce soil newly taken from a field and enriched with fresh manure. Several of these growers here have observed that a good baking of this used soil restores its value again; in fact, it becomes too rich and begins to supply the plant with an excessive amount of nitrogen. It has also been pointed out that it was the custom of certain of the Bombay tribes to burn vegetable rubbish mixed as far as possible with the surface soil before sowing their crop, and the value of this practice in European agriculture, though forgotten, is still on record in the books on Roman agriculture. We can go back to the Georgics again, and there find an account of a method of heating the soil before sowing, which has only received its explanation within the last year, but which in some form or other has got to find its way back again into the routine of agriculture. Indeed, I am informed that one of the early mysteries, many of which we know to be bound up with the practices of agriculture, culminated in a process of firing the soil, preparatory to sowing the crop.

My time has run out, and I fear that the longer I go on the less you will feel I am presenting you with any solution of the problem with which we set out—"What is the cause of the fertility of the soil?" evidently there is no simple solution; there is no single factor to which we can point as *the* cause; instead we have indicated a number of factors any one of which may at a given time become a limiting factor and determine the growth of the plant. All that science can do as yet is to ascertain the existence of these factors one by one and bring them successively under control; but, though we have been able to increase production in various directions, we are still far from being able to disentangle all the interacting forces whose resultant is represented by the crop.

One other point, I trust, my sketch may have suggested to you—when science, a child of barely a century's growth, comes to deal with a fundamental art like agriculture, which goes back to the dawn of the race, it should begin humbly by accepting and trying to interpret the long chain of tradition. It is unsafe for science to be dogmatic; the principles upon which it relies for its conclusions are often no more than first approximations to the truth, and the want of parallelism, which can be neglected in the laboratory, gives rise to wide divergencies when produced into the regions of practice. The method of science is, after all, only an extension of experience. What I have endeavored to show in my discourse is the continuous thread which links the traditional practices of agriculture with the most modern developments of science.

The contribution by Prof. R. A. Fessenden read at the British Association, on the power to be derived from the wind and sun, elicited some remarkable figures, and suggested that the method is now practicable on a commercial scale. The initial difficulty in determining the probable efficiency of such a scheme is that the solar "constant" is itself an uncertain quantity. Prof. Fessenden regards it as being equivalent to about 150 pounds per square foot per second, but he himself thinks that this is somewhat high. Pouillet's experiments, as described by Prof. Minchin, reduce the figure to 63.42, while the corresponding figure derived from Violle's tests is 91.35. The measurements made by Prof. Very also illustrate the great diversity that exists in the available solar energy at different points and times on the earth's surface and under various conditions of incidence. Prof. Fessenden's investigation of the comparative costs of storage by batteries and storage by a sunk-tank hydraulic system is of importance, and his figures, deserve attention. For his main generators he proposes to use a low-pressure steam turbine, or a special type of engine of which the description is not yet published, and that an efficiency of 10 per cent is estimated for this portion of the plant. Further, the whole undertaking is to be assisted, when and where possible, by windmills; and the general conclusion of Prof. Fessenden is that in cases where water-power is not directly available, a solar-radiation plant, or a windmill plant, comes within the range of engineering possibilities. Sooner or later, when the mineral resources of this country become too costly for power production purposes, some such scheme will be inevitable, and, assuming that sunshine and the winds of heaven escape predatory taxation, they will have to be made available for driving the world's machinery.—London Times.

THE METEOROLOGICAL ISOGRAMS.

A RAPIDLY GROWING FAMILY OF CURVES DESCENDED FROM ALEXANDER VON HUMBOLDT'S "ISOTHERMS."

BY C. FITZHUGH TALMAN.

ISOGRAM is the convenient generic name proposed by Sir Francis Galton for lines on charts and diagrams connecting places at which equality of some physical condition has been found, or is assumed, to exist. These lines are used in many sciences, but the largest number of those to which particular names have been assigned belong to meteorology.

Every one who has even the most rudimentary knowledge of physical geography is familiar with at least two of the meteorological isograms; viz., the *isotherm* and the *isobar;* the line of equal temperature and the line of equal barometric pressure. In common with most of the other isograms the isotherm and the isobar are used to represent either the mean or the instantaneous distribution of the elements to which they refer. The former use is illustrated in the ordinary climatic chart; the latter in the synoptic weather map.

To the prolific genius of Alexander von Humboldt was due the introduction of the isogram into climatology, but the idea was borrowed from terrestrial magnetism. The earliest magnetic isograms were Halley's lines of equal magnetic declination (long after Halley's time named *isogonic lines* by C. Hansteen), published in 1701, and several other charts of magnetic isograms had been published before the appearance, in 1817, of Humboldt's "Carte des lignes isothermes," accompanying his memoir on the distribution of temperatures over the globe. In his "Prologomena," published the same year, occurs the first use of the word *isotherm*: "Ita videmus circulos aequalis caloris annui, sive, ut novo vocabulo utamur, *isothermos*."

Humboldt also suggested the use of two other meteorological isograms: viz., the *isothere*, connecting places having the same temperature in summer, and the *isochimenal*, connecting those having the same temperature in winter; but he did not actually publish them. He contented himself with a description of their course with respect to the annual isotherms, and with noting the summer and winter temperatures at several points on his isothermal chart. (See Fig. 1.)

Theoretical isobars for the Atlantic and Indian oceans were drawn by H. W. Berghaus in 1839; in accordance with the views then prevailing they were straight lines parallel to the equator. The first isobars based upon actual data of observation were those drawn for France by Renou, in 1864, and the first isobars for the whole globe were published by Buchan (who called them *isobarometric lines*) in 1868.

In recent years the number of named isograms has increased rapidly, but they have received tardy recognition in the dictionaries, and even in scientific reference-books. One result of this is seen in the frequent coining of synonymous expressions. A writer who finds it convenient to apply a name to an isogram cannot readily ascertain whether a suitable name has already been proposed; he therefore proceeds to christen it "à sa guise."

The naming of isograms has been somewhat haphazard, and this branch, as well as others, of meteorological terminology stands in need of revision by a competent international commission, the creation of which has recently been suggested to the International Meteorological Committee. A conspicuous example of an ill-named isogram was Kämtz's *isobarometric line*, which was defined as a line of equal mean monthly range of barometric pressure. Although Kämtz himself admitted that the name was a "misfit," it was very frequently used in the middle of the nineteenth century, until Buchan, in 1868, applied this term properly to the isobar.

Other isograms that are not happily named are those belonging to the class known as *isochrones*, which are used to indicate the simultaneous occurrence of a phenomenon at several points. Inasmuch as a majority of the isograms denote equal *quantity* or *intensity*, it would tend to prevent confusion if the isochrones had some prefix other than *iso-*. Thus the isobronts of a thunderstorm (see Fig. 6) might better be called *homobronts* (a name that has, in fact, been frequently applied to them); since, by analogy with most of the names formed on the same prefix, *isobront* appears to mean a line of equal thunderstorm-frequency, or perhaps of equally loud thunder. A still better prefix might be *syn-* or *hama-;* either of which is a more nearly literal expression of the meaning intended; however, "a name is a name, and not a definition," and consistent usage is the principal desideratum.

The application of the names of the isograms is, and should be, somewhat elastic. Thus an isotherm is *any* isogram of temperature; not merely of mean annual temperature, as was stated, until very recently, in the English dictionaries. Similarly, the *isotalantose* should be defined as *any* isogram of range; the element and period in question being indicated by a qualifying expression when necessary; but as a rule this can be gathered from the context. In other words, the names of the isograms should have a more or less generic application; otherwise the terminology of these lines would need to be multiplied *ad infinitum* to satisfy all the requirements of the graphic representations used in meteorology.

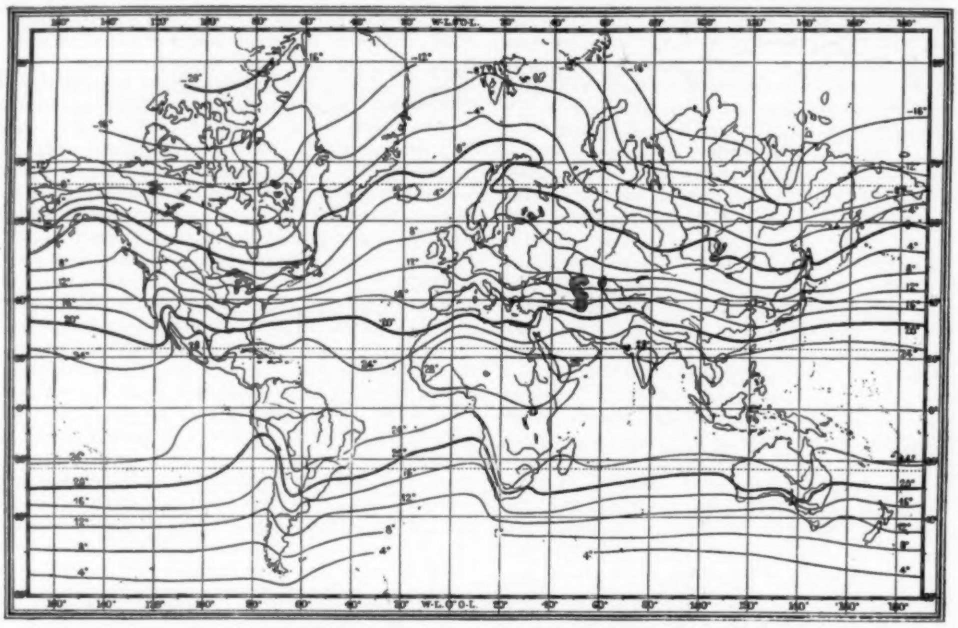


FIG. 2.—A MODERN ISOTHERMAL CHART OF THE GLOBE. (HANN, 1901.)

The isotherms show the mean annual temperature in Centigrade degrees; they are based on the records of many thousand stations.

The following list of the meteorological isograms has been collected from a wide range of literature, in many languages, and is believed to be a nearly complete enumeration of this class of words. The author will be glad to have his attention called to any that he has overlooked. The isograms of terrestrial magnetism, and many isograms that are of general application in physics, and are therefore occasionally met with in meteorological diagrams (e. g., *isenergic* and *isentropic*), lie beyond the scope of the present compilation.

LIST OF METEOROLOGICAL ISOGRAMS.

choroisotherm. An isotherm used in representing the distribution of temperature in space; the common form of isotherm, as on isothermal maps and weather maps; distinguished from the *chronoisotherm*, which shows the distribution of temperature in time. (W. Köppen.)

chronoisotherm. An isopleth of temperature; a thermoisopleth. (R. H. Scott.)

chthonisotherm. Name proposed by G. Bischof, in 1837, for a line drawn from the equator poleward along a meridian, passing through points beneath the earth's surface having the same temperature as the surface at the equator.

equiglacial line. Isogram of the condition of the ice in rivers, lakes, harbors, etc. There are three classes of these lines; viz., *isopectics*, *isotacs*, and *isopags* (all defined below). Some writers apply this term only to the isopag.

geoisotherm (geisotherm). Same as *isogeotherm.*

homobront. Same as *isobront.*

hypertherm. Isogram of positive departure from normal temperature. (H. Arctowski.)

hypotherm. Isogram of negative departure from normal temperature. (H. Arctowski.)

hypsoisotherm. An isotherm drawn on a vertical section of the atmosphere (sometimes also of the ground) to show the distribution of temperature in the vertical.

isabnormal (isoabnormal). Same as *isanomal.*

isalea. Isogram of the amount of insolation, expressed in thermal units. (J. Westman.)

isallobar. Isogram of the amount of change in barometric pressure within a specified period.

isallotherm. Isogram of the amount of change in temperature within a specified period. (This name has possibly not heretofore been used. It is, however, the natural designation of a very common isogram,

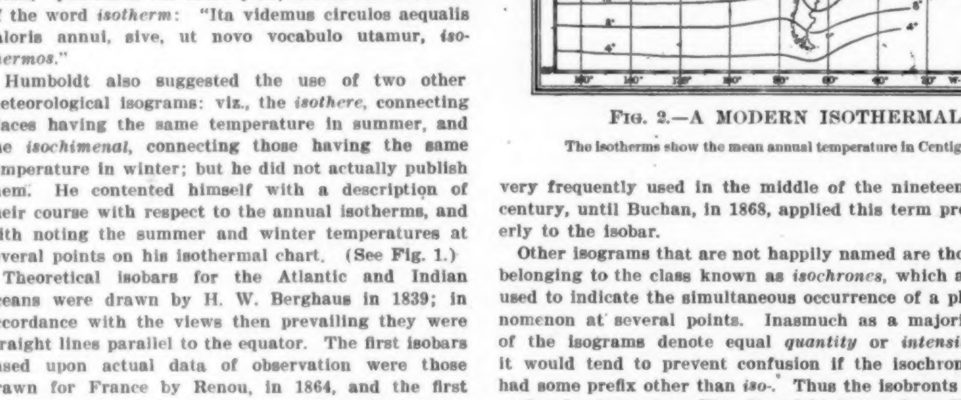


FIG. 1.—HUMBOLDT'S ISOTHERMS OF THE NORTHERN HEMISPHERE (1817). THE FIRST CHART OF METEOROLOGICAL ISOGRAMS.

In Humboldt's time climatology was an infant science; he was able to find only 58 stations, scattered over the world, whose mean annual temperatures were known with sufficient precision to be utilized in the construction of his chart. Although far from being an accurate presentation of the geographical distribution of temperature, Humboldt's isotherms reveal the important fact that temperature does not run parallel with latitude; the northward trend of the isotherms over western Europe, and their southerly trend over the American and Asiatic continents, is clearly shown. He assumed, however, that the temperature of the equator was everywhere 27,5 deg. C.

which is otherwise nameless, and the author therefore ventures to include it in the list.)

isametral. Isogram of the temporary departure of an element, during a particular period, from the local normal. (H. W. Dove.)

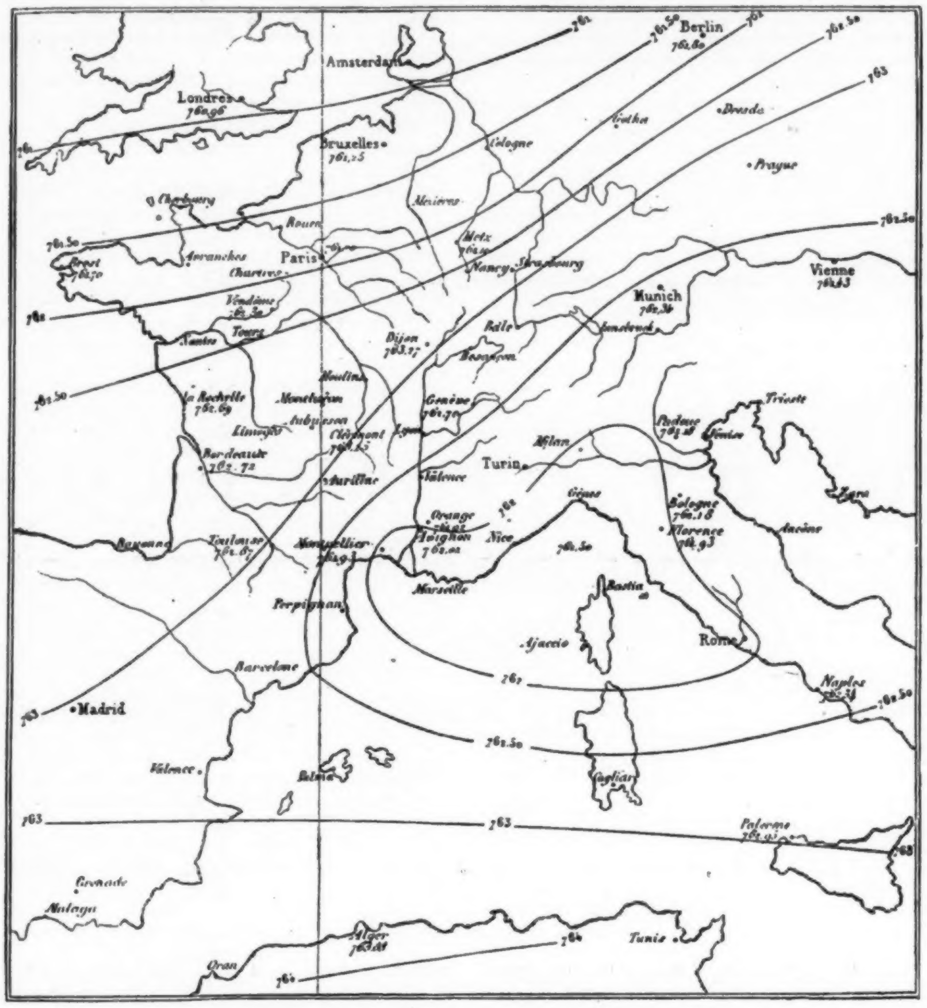


FIG. 3.—THE FIRST CHART OF ISOBARS. RENOU'S ISOBARIC CHART OF FRANCE (1864).

This shows the mean annual barometric pressure in millimeters. The first charts of this character embracing the whole globe were Buchan's—for each month and for the year—published in 1868.

isanemone. Isogram of wind-force or wind-velocity. (L. Brault.)

isanomal (*isanomalous line*). Isogram of anomaly; i. e., of the departure of the local mean value of an element from the mean pertaining to the latitude.

isanthesic line (*isanthesical line; isantheric line; isanther*). In phenology, the isochrone of the first blossoming of any specified plant. (Quetelet.)

isoabnormal. See *isabnormal.*

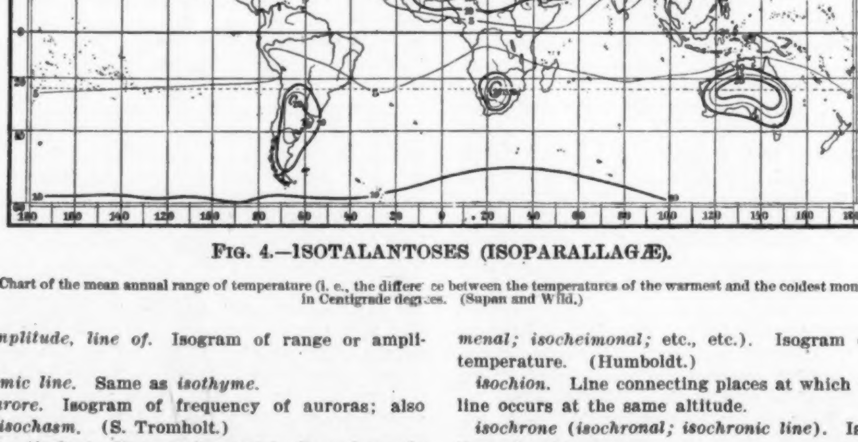


FIG. 4.—ISOTALANTOSES (ISOPARALLAGÆ).

Chart of the mean annual range of temperature (i. e., the difference between the temperatures of the warmest and the coldest months) in Centigrade degrees. (Supan and Wild.)

isoamplitude, line of. Isogram of range or amplitude.

isoatmic line. Same as *isothyme.*

isoaurore. Isogram of frequency of auroras; also called *isochasm.* (S. Tromholt.)

isobar (*isobaric line; isobarometric line;* formerly also *isobare,* which is the French form unanglicized). Isogram of barometric pressure.

isobarometric line. Isogram of mean monthly range of barometric pressure. (Kämtz, 1827. Disused in this sense.)

isobathytherm (*isothermobath*). Isotherm of the water of the ocean, etc., in vertical section.

isobront (*isobrontal line; isobronton*). A thunderstorm isochrone; usually an isochrone of the first thunder, loudest thunder, or beginning of rain in a thunderstorm. Also called *homobront.* (Bezold and Lang.)

isochasm. Same as *isoaurore.* (H. Fritz.)

isocheim (with many variants: *isocheimal; isochimenal; isocheimonal;* etc., etc.). Isogram of winter temperature. (Humboldt.)

isochion. Line connecting places at which the snow-line occurs at the same altitude.

isochrone (*isochronal; isochronic line*). Isogram of time of occurrence.

isocryme (*isocrymal; isocrymic line*). Isotherm for a specified coldest period of the year—applied chiefly to water-temperatures. (J. D. Dana.)

isodense. Same as isopycnic line. (N. Ekholm.)

isodiaphore. Isogram of difference; e. g., between

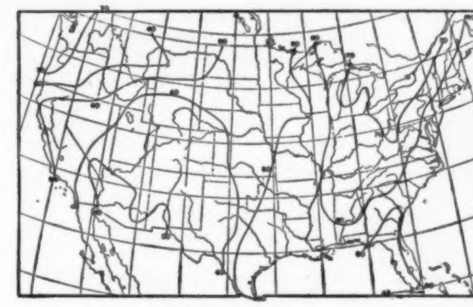


FIG. 5.—ISONEPHS OF THE UNITED STATES IN MIDWINTER. (AFTER GREELY.)

Isonephs connect the places, shown on a map, which have the same degree of cloudiness (usually mean cloudiness) during a specified period. In this case the cloudiness is expressed in percentage; 0 representing a cloudless sky, 100 a sky that is completely overcast. It will be seen from the chart that the regions of maximum cloudiness in midwinter in the United States are the extreme northwest and the eastern lake region, while the clearest skies are in the far southwest.

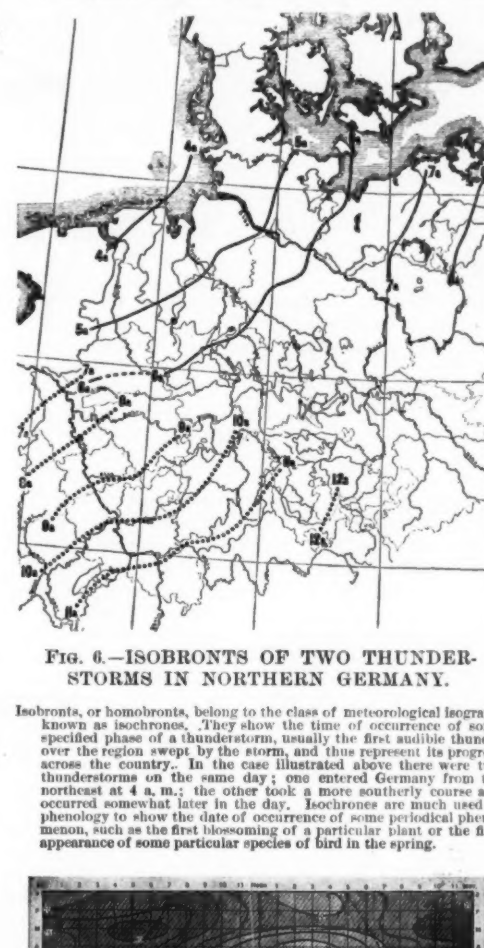


FIG. 6.—ISOBRONTS OF TWO THUNDERSTORMS IN NORTHERN GERMANY.

Isobronts, or homobronts, belong to the class of meteorological isograms known as isochrones. They show the time of occurrence of some specified phase of a thunderstorm, usually the first audible thunder over the region swept by the storm, and thus represent its progress across the country. In the case illustrated above there were two thunderstorms on the same day; one entered Germany from the northeast at 4 a. m.; the other took a more southerly course and occurred somewhat later in the day. Isochrones are much used in phenology to show the date of occurrence of some periodical phenomenon, such as the first blossoming of a particular plant or the first appearance of some particular species of bird in the spring.

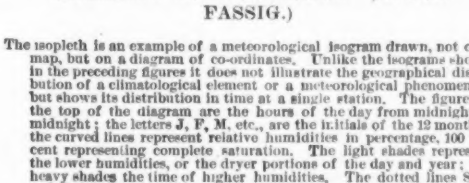


FIG. 7.—ISOPLETHS OF THE RELATIVE HUMIDITY AT BALTIMORE. (AFTER FASSIG.)

The isopleth is an example of a meteorological isogram drawn, not on a map, but on a diagram of co-ordinates. Unlike the isograms shown in the preceding figures it does not illustrate the geographical distribution of a climatological element or a meteorological phenomenon, but shows its distribution in time at a single station. The figures at the top of the diagram are the hours of the day from midnight to midnight; the letters J, F, M, etc., are the initials of the 12 months; the curved lines represent relative humidities in percentage, 100 per cent representing complete saturation. The light shades represent the lower humidities, or the dryer portions of the day and year; the heavy shades the time of higher humidities. The dotted lines S.R. and S.S. indicate the time of sunrise and sunset respectively. The diagram is based on the 30 months' record of a Richard hygrograph. This convenient diagram shows at a glance the mean relative humidity at every hour of the day during each month of the year.

the mean values of an element for two specified months. (R. Spitaler introduced this term in a comparison of the unreduced barometric pressure at different seasons.)

isodrome. Similar to *isodiaphore,* but applied by its author, F. von Kerner—chiefly in the form *thermoisodrome*—to a comparison of spring and autumn temperatures.

isodynam. An isogram of force; in meteorology,

generally of wind-force, and then synonymous with *isanemone*.

isoeral. Isogram of the temperature in spring.

isogeotherm. Isogram of the temperature of the ground; also called *geisotherm* or *geoisotherm*.

isogradient. Isogram of gradient; applied by J. Kleiber to the isogram of horizontal pressure-gradient.

isogram. The generic name of lines that indicate equality. (F. Galton, 1889.) In German these have occasionally been called *Isolinien* ("iso-lines").

isohel (*isohelic line*). Isogram of duration of sunshine.

isohyet (*isohyetal; isohyetose*). Isogram of the amount of rainfall.

isohygrometric line. Isogram of atmospheric moisture.

isohyst. Same as *isohyet*.

isomenal. Isogram of a monthly mean; especially of temperature.

isometoporal. Isogram of the temperature in autumn.

isoneph (*isonephelic line*). Isogram of cloudiness. (E. Renou.)

isoomber. An untenable synonym of *isothyme*.

isopag. The equiglacial line indicating the duration of the ice-cover in rivers, harbors, lakes, etc. (K. L. Vesselovskii.)

isoparallage. Same as *isotalantose*. (F. W. C. Krecke.)

isopectic. The equiglacial line of the first ice in winter. (M. Rykachev.)

isophenomenal. 1. A weather isogram, in general. 2. A phenological isochrone.

isophane. Generally identical with *isanthesic line*; but the term is applicable to other phenological isochrones. (Hoffmann.)

isophasm. Term applied by W. Krebs to an isogram of the range of barometric pressure.

isophenological line. Any phenological isochrone.

isopleth. A line on a diagram showing the occurrence of equal quantities, etc., of any phenomenon in relation to two independent co-ordinates. The commonest form used in meteorology is illustrated in Fig. 7; in another common form one of the co-ordinates represents altitude or depth, etc. (Introduced into meteorology by L. Lalanne; named by Ch. Vogler.)

isopycnic line (*isopyc*). Isogram of atmospheric density; also called *isodense* and *isostath*.

isostath (*isostathmic line*). Same as *isopycnic line*. (C. Abbe.)

isostere. Isogram of specific volume.

isothene. Line of atmospheric equilibrium. (M. Möller.)

isotac. The equiglacial line of the breaking up of the ice in spring. (M. Rykachev.)

isotalantose (*isotalantous line*.) Isogram of range or amplitude; generally applied to the mean annual range of temperature. (A. Supan.)

isothere (*isotheral*). Isogram of the temperature in summer. (Humboldt.)

isotherm (*isothermal*). Any isogram of temperature.

isothermobath. Same as *isobathytherm*.

isothermohyps. A thermoisopleth, one co-ordinate of which is altitude.

isotherombrose. Isogram of summer rainfall.

isothyme. Isogram of amount of evaporation. (Marvin and Talman.)

synthermal. An isotherm based on simultaneous observations. (Century Dict. Suppl.)

thermoisodrome. Isogram of the "thermodromic quotient"—a mode of expressing the ratio between spring and autumn temperatures, devised by F. von Kerner.

thermoisopleth. An isopleth of temperature.

RECENT STUDY OF RADIUM.

NEW RESEARCHES IN THE FIELD OF RADIOACTIVITY.

BY PROF. F. HENRICH.

THE hypothesis of the disintegration of atoms continues to prove a valuable aid in the study of radioactivity. The idea that atoms are complex is not new, but it was laid aside for a long time because no instance was known, either of the disintegration of an atom or of its formation from smaller atoms. No instance of the last named transformation is yet known, but the discovery of cathode rays and electrons led to the assumption that the atoms of chemical elements contain small electric particles (electrons), which can be separated and which have a mass 1/2000 that of the hyrogen atom. The increasing knowledge of radioactive substances developed a theory of atomic disintegration, occurring in an explosive manner and following the laws of chemical reaction, but with a reaction velocity which has not yet been affected by external influences. The cause of this disintegration is still entirely unknown. It takes place spontaneously in a few elements of high atomic weight, and is accompanied by the emission of radiations of three kinds. Two of these, the Alpha and Beta rays, are of material nature and are deviated by electric and magnetic forces, while the third, the Gamma rays, resemble Röentgen rays and are not thus deviated. A few elements of the radioactive series emit no rays in their disintegration.

An apparent radioactivity, or pseudo-radioactivity, manifested by the blackening of photographic plates, is exhibited by polished metals, and must be carefully distinguished from genuine radioactivity. Dombrowsky and Saeland have discovered, independently, that this metallic emanation can be blown away by an air current and is not affected by magnetic or electric force, and that the presence of oxygen and moisture is required for the production of the photographic effect. Hence it is probable that this effect is caused by hydrogen dioxide, which in a solution of 1 to 1,000,000 blackens photographic plates. Ebler and Krause have shown that hydrogen dioxide may be produced in these cases by the decomposition of higher metallic oxides, which are formed by the action of oxygen upon the polished surface. The strongest of these metallic radiations is produced by zinc. The freshly formed superoxide Zn_2O_3 acts as strongly as uranium on photographic plates, and the effect increases with the quantity of moisture present. Similarly, lower oxides can become converted into peroxides, which then produce hydrogen dioxide, under the influence of moisture.

Rutherford soon concluded that Alpha particles are electrified atoms of helium, and many experimental facts support this view. Rutherford and Royds have lately obtained a direct proof by surrounding a sealed glass tube 1/2500 inch thick, in the interior of which no helium could be detected, with an atmosphere of Alpha particles. After a time helium was detected inside the tube. The experimenters concluded that Alpha particles, in consequence of their great velocities, traversed the thin tube, lost their electric charge and thus became converted into helium. The Alpha particle had already been proved to carry a double electric charge. Its kinetic energy is so great that it passes directly through the molecules of gases, and in its course produces from 100,000 to 200,000 ions. After traveling a certain distance it suddenly loses this ionizing power and thus becomes imperceptible. This distance, called the range, varies from 1.2 to 3/2 inches with the element by which the Alpha radiation is emitted.

The ejection of an Alpha particle from an atom diminishes the atomic weight by four units. The tables given below show how uranium may be converted into lead by a series of such losses. The Alpha particles were first counted by Rutherford and Geiger, by means of the effect produced upon an electrometer by gases ionized by these particles. In this way it was found that 4×10^{10} Alpha particles are emitted by 1 gramme of radium in one second. A second method is based on the fact that each Alpha particle, on striking a screen covered with crystallized zinc sulphide, produces a flash of light. The phenomenon is called scintillation and was discovered by Crookes. By this method Regner has counted the Alpha particles and obtained results closely accordant with Rutherford's.

The study of Alpha particles has contributed greatly to reviving the hypothesis of the material nature of atoms, which has in recent years had a revival in the energetic theory. The transformation of Alpha particles into atoms of helium has furnished data for the calculation of important atomic constants. Two of these are the number of molecules in a cubic centimeter of gas (N) and the electrical charge of an ion (e). The results obtained by these methods are

$$N = 2.77 \times 10^{19}$$
$$e = 4.65 \times 10^{-10}$$

These values agree closely with those obtained by totally different methods and by Planck's theoretical calculations. Planck's values are

$$N = 2.8 \times 10^{19}$$
$$e = 4.69 \times 10^{-10}$$

This remarkable coincidence affords a striking proof of the correctness of the atomistic theory of matter and electricity.

The study of the optical properties of fine suspensions, combined with studies of the Brownian molecular motion, by Svedberg and Perrin, also proves the bodily existence of molecules in solutions.

We have every reason, therefore, to regard the chemical atom as a well-defined unit in the subdivision of matter, but it is no longer the smallest known quantity of matter. Radioactive phenomena show that atoms may be composed of Alpha particles and electrons. Geiger has discovered that Alpha rays are dispersed after traversing a very few atoms, showing that the atom is the seat of a strong electric field. A new idea, that of reaction, has lately been added to the theory. When certain substances are exposed to the action of actinium salts they acquire a radioactive deposit of actinium *A*, *B*, and *C*, which is quickly disintegrated, as a glance at the actinium table below will show. It has been repeatedly observed, however, that in these cases a small remnant of radioactivity persists for a long time. If the experiment is performed in an electric field, the residual activity is greatly increased and may amount to one-fourth of the initial activity. Hahn has shown that this residual activity is due to actinium *X*. Now, how could actinium *X*, which is a solid, be carried from the actinium salt to the body displaying induced radioactivity? Between radioactinium and actinium *X*, in the series, neither a gas at high pressure nor a short-lived emanation has been detected. A satisfactory explanation is given by the assumption that radioactinium disintegrates explosively into actinium *X* and one Alpha particle per atom, and that the separation is so violent that the actinium *X* experiences a reaction, which is sufficient in some cases to eject it from the molecule. In a negative electric field the nascent positively charged atoms of actinium *X* would be freed from the molecular bonds still more readily. Rutherford has obtained similar results with radium. Rhus and Makower condensed radium emanation, containing its products of disintegration, radium *A*, *B*, and *C*, in quantities corresponding to radioactive equilibrium, in the bottom of an exhausted tube immersed in liquid air, and found that particles of the active deposit were carried to the upper part of the tube. Radium *A*, *B*, and *C* disintegrate explosively, ejecting Alpha particles and producing a reaction upon the remnant of the atom, which occasionally expels it from the solid mass. This phenomenon of reaction provides a new method of discovering and separating radioactive substances. By this method thorium *D* has been discovered and actinium *C* can be separated more easily than by chemical methods.

The question whether radioactivity is common to all elements was first studied experimentally by Madame Curie, who found that no element except uranium and thorium exhibited more than one per cent of the activity of uranium. Campbell subsequently, by a very sensitive method, obtained results indicating the existence of other radioactive elements, especially potassium, rubidium and lead. Elster and Geitel, however, showed that the apparent radioactivity of lead is due to the presence of impurities containing radium *F*. Levin and Ruer have recently made a comprehensive study of all groups of elements by a photographic method, which has the advantage of being very sensitive, because cumulative action can be employed. The photographic plates were wrapped in black paper, and on their sensitive sides perforated sheets of brass were laid. The substances under investigation, wrapped in paper, were placed in the perforations. The exposure was continued six months. The paper wrappings prevent the detection of Alpha rays by this method.

Of the elements of the first group of the periodic system only potassium and rubidium affected the plate. In the second group an effect was observed only with salts of beryllium, and this was due partly to contamination with radium. In the third group lanthanum produced an effect, which also may have been due to impurities. Similar results were obtained with the elements of the fourth group. Lead from water pipes unearthed at Pompeii, and lead mined one hundred years ago, produced no perceptible effect. The photographic plate was blackened only by compounds of cerium, but as the activity of these compounds varied with their source, it was probably due to impurity. In the fifth group niobic and tantalic acids blackened the plates slightly, although no contamination with thorium or radium could be proved.

If, however, niobium possesses true radioactivity this is ten times smaller than that of potassium and the radioactivity of tantalum must be much smaller yet. In the group of the rare earths, only one compound of erbium and one of neodymium exhibited a radioactivity equal to one-tenth that of potassium. None of the elements of the remaining groups produced any perceptible effect on the photographic plates.

From the above and other investigations it appears that true radioactivity is possessed at least by potassium and rubidium, in addition to the typical radioactive elements. The activity of potassium and rubidium can hardly be due to impurities, as it has been found impossible to increase it by fractional separation of any kind. Potassium emits Beta rays. Rubidium apparently emits both Beta and Alpha rays, as part of the radiation is absorbed by paper. Hence the two metals cannot contain the same active principle. No disintegration product of either has yet been detected.

Now let us turn to the typical radioactive elements with their series of disintegration products. These elements are uranium, actinium and thorium. A number of additions were made to the uranium series last year. Dunne discovered an intermediate product between uranium and uranium X, which he calls radio-uranium, or U'. Four years ago Soddy prepared solutions of uranium salts, free from radium, for the purpose of studying the transformation of uranium into radium. After a time radium was detected in these solutions. The quantity of radium increased with the square of the time. If we assume between uranium and radium a single, long-lived intermediate product (ionium) the observations made on these solutions lead to a half period of 18,500 years, but observations of fresher solutions of pure uranium salts were found to produce a quantity of radium smaller than this period called for. Soddy endeavors to harmonize the results of theory and experiment by inserting between uranium X and ionium another intermediate product, with a half period of one year, which he calls uranium A.

The experimental evidence for the existence of uranium A is still very scanty, but the existence of ionium has been fully confirmed by recent investigations. Ionium is the direct parent of radium. Boltwood showed that ionium is chemically very similar to thorium, and that it emits Alpha rays of less 1.2 inch range and becomes converted into radium at a uniform rate. Keetman has elaborated a method of separating ionium from the rare earths and other mixtures. Ionium is found associated with uranium in constant proportions in all uranium ores, and it must therefore be a derivative of uranium. Its radioactivity is 34 per cent that of uranium.

Stock and Heynemann find that radium bromide does not volatilize appreciably below 1,650 deg. F. It is therefore, as its position in the periodic system would suggest, less volatile than the barium bromide. By fractional sublimation a residue containing an increased proportion of radium was obtained from mixtures of barium and radium compounds. This result has a practical bearing upon the production of radium.

Progress has been made in the study of radium emanation, which is one of the most important of radioactive substances. Rutherford, and also Ramsay and Gray, have condensed the emanation into the liquid and solid forms. The liquid emanation is colorless, but emits a faint bluish green phosphorescence. By spraying with liquid air a tube, which is filled with the emanation and covered with cotton wool, a solid of steel blue metallic sheen is obtained. When the cooling is carried further, the color changes successively to white, yellow, and orange, and when the solid emanation is allowed to become warmer, these colors appear in the reverse order. The boiling point of the emanation is —80 deg. F. according to Ramsay and Gray and —85 deg. F. according to Rutherford. Its melting point is —96 deg. F., its critical temperature is 220 deg. F., its critical pressure is 1.87 inches of mercury. Its atomic weight should be 222, according to the disintegration theory, but the experiments of Ramsay and Gray give the value 176.

Royds has studied the spectrum of radium emanation with a concave grating of 40 inches radius. His results agree with those of other observers.

Many attempts have been made to utilize the immense energy possessed by radium emanation. Ramsay and Cameron have found that small quantities of lithium and argon are produced by the action of the emanation upon aqueous solutions of copper sulphate and copper nitrate. Mme. Curie and Mlle. Gleditsch, who repeated these experiments, employing vessels of platinum, obtained no trace of lithium or argon, and they suggest that the lithium detected by Ramsay and Cameron may have been derived from the glass vessels which they used. Perman has exposed copper and gold to the action of radium bromide without obtaining any evidence of a transmutation of these metals. Ramsay, however, insists upon the accuracy of his observations. Ramsay and Usher have published experimental evidence of the transmutation of thorium, lead, zirconium, titanium and silicon, into carbon, a member of the same group of elements. The experiment was arranged as follows: The quantity of gas (25 cubic centimeters) evolved in one week by an aqueous solution of radium bromide containing 0.21 gramme of radium was exploded, leaving 0.5 cubic centimeter of residual gas, containing 0.09 cubic centimeter of radium emanation. This half thimbleful of gas was then introduced into a small tube with moist potassium hydroxide and, thus freed of carbon dioxide, was transferred *in vacuo* to a bulb containing the solution which was to be acted upon by the emanation. The gas was allowed to act during four weeks, in which time its energy was exhausted. The bulbs contained solutions of hydrogen silicon fluoride, titanium sulphate, zirconium nitrate, thorium nitrate and lead chlorate. Carbon dioxide was found in all, and carbon monoxide in a few of the bulbs. The experiments were checked by treating a solution of mercurous nitrate in a similar manner. In this solution no trace of carbon was found. The quantity of carbon produced by one cubic millimeter of emanation varied from 0.1 to 3 milligrammes.

These experiments appear to indicate the production of carbon by the disintegration of heavier atoms belonging to the same periodic system, under the influence of radium emanation, but these transmutations cannot be accepted without reserve until they have been confirmed by other observers in experiments in which all sources of error, especially the use of glass vessels, have been avoided.

Giesel has found that water is decomposed by radium salts dissolved in it. Ramsay asserted that in this reaction an excess of hydrogen was always produced, but Debierne obtained only detonating gas with no excess of hydrogen. Ramsay's statement, however, may be correct, for Kernbaum has found that in certain conditions hydrogen dioxide is also formed. The reaction is probably caused by Beta rays, for Debierne obtained it by means of radium separated from the water by glass. A solution containing one gramme of radium evolves daily 13 cubic centimeters of the detonating mixture of oxygen and hydrogen.

It has been believed that radium emits only Alpha rays, but according to Hahn and Meitner it appears to send out also Beta rays which, however, are "soft" i. e. readily absorbed. Possibly radium is complex and first produces a radium X, which is the parent of the emanation.

Makower finds that radium A possesses appreciable vapor tension at 1,475 deg. F. and is completely vaporized at 1,650 deg. F. The boiling point of radium B is probably below 1,300 deg. F. Radium C, deposited on platinum or nickel is completely volatilized at 2,200 deg. F., but when deposited on quartz a solid residue remains at 2,375 deg. F. In contrast to radium A and radium B, radium C exhibits no electric charge at the moment of its production. According to recent investigations by Hahn and Meitner, radium C is not a single substance. It appears to contain a second very short-lived element, which cannot be isolated by slow chemical methods. These experimenters call the formerly known substance, with a half-period of 19 minutes, radium C, and the short-lived new element radium C_2. The accompanying table gives the present condition of the uranium series, doubtful elements being bracketed.

The occurrence of uranium and actinium together in constant proportion indicates that actinium may be a derivative of uranium. McCoy and Rohs conjecture that uranium X produces uranium A and actinium simultaneously, but there is no certain evidence of this transformation.

The present state of our knowledge of the actinium and thorium series is expressed in the accompanying tables. The experiments of Blanc and Joly indicate that thorium is very widely distributed in surface rocks and that it plays a very important part in the radioactivity of the earth.

Stroemholm and Svedberg have found in isomorphism a valuable means of determining the chemical nature of radioactive substances. When various salts were crystallized from solutions containing radioactive substances, only those salts which were isomorphous with the radioactive substance exhibited any radioactivity. For example, salts of potash, magnesium and lanthanum, crystallized from solutions containing actinium X, were wholly inactive, but barium and lead salts crystallized from solutions containing actinium X were found strongly active. The experimenters infer that actinium X belongs to the group of metals of the alkaline earths. The behavior of thorium X is identical with that of actinium X. In a similar way, actinium was shown to be isomorphous with lanthanum, radioactinium, and thorium, and the last named element with radiothorium.

These investigations have already given valuable data for the classification of radioactive elements. A marked parallelism is exhibited by the series of derivatives of the three principal radioactive elements. In each series the emanation is immediately preceded by an element apparently belonging to the group of the alkaline earth metals, and chemically very similar to them. These elements in turn are immediately preceded by radiothorium, radioactinium and ionium, of which the first and second are isomorphous with thorium, while ionium, which has not yet been studied in this respect, resembles thorium in its chemical reactions. The emanations appear to be gases of the argon series.

Radium is now obtainable in somewhat larger quantities than hitherto. Radium salts obtained from the uranium mines of St. Joachimsthal are now offered for sale by the Austrian government. In England, radium is obtained from uranium ores, by Ramsay's process and a "radium bank" has been established for the loan of radium and its salts to experimenters.

It is well known that the accessible strata of the atmosphere contain ions, which are continually reproduced, chiefly by the action of the radioactive emanations which are always present in the capillary channels of the earth. These emanations diffuse into the atmosphere, especially with a falling barometer, and sometimes rise to great heights. Flemming detected radioactivity in the atmosphere at an elevation of ten thousand feet. In general, the atmosphere is more strongly radioactive at great heights than at the earth's surface. Ebert and Evers have proved that the observed effects are due to radium and thorium emanations in conjunction, and the emanation of actinium can also be detected occasionally. Brandes finds from an extensive series of measurements that the quantity of emanation in the air of the soil increases rapidly at first with the depth, but attains a maximum at a depth of 2 yards. Mache's calcula-

URANIUM SERIES.

	Half Period.	Rays Emitted.
Uranium	5.8×10^9 years	α
↓ (Radio-uranium or U')	....	....
↓ Uranium X (U'')	22 days	β-γ
↓ (Uranium A)	1 year	α
↓ Ionium	2000-3000 years	α, β
↓ Radium	1,900 years	α
↓ Radium emanation	3.75 days	α
↓ Radium A	3 minutes	α
↓ Radium B	26 minutes	β
↓ Radium C_1	19 minutes	α, β, γ
↓ (Radium C_2)	Very short	....
↓ Radium D (radio-lead)	12 years	none
↓ Radium E_1	6 days	none
↓ Radium E_2	4.8 days	β
↓ Radium F (polonium)	140 days	α
↓ Lead (?)	. ....	...

ACTINIUM SERIES.

	Half Period.	Rays Emitted.
Actinium	. ...	none
↓ Radio-actinium	19.5 days	α
↓ Actinium X	10.2 days	α
↓ Actinium emanation	3.9 seconds	α
↓ Actinium A	36 minutes	none
↓ Actinium B	2.2 minutes	α, β
↓ Actinium C	5.1 minutes	....

THORIUM SERIES.

	Half Period.	Rays Emitted.
Thorium	....	α
↓ Thorium 1 } Mesothorium	5.5 years	none
↓ Thorium 2 } Mesothorium	6.2 hours	β
↓ Thorium 3 (radio-thorium)	738 days	α
↓ Thorium X	3.6 days	α
↓ Thorium emanation	54 seconds	α
↓ Thorium A	11 hours	β
↓ Thorium B	55 minutes	α, β, γ
↓ Thorium C	A few seconds	α, β, γ
↓ Thorium D	3.1 minutes	β

tions prove that the diffusion of these emanations from the soil is sufficient to maintain the normal ionization of the atmosphere, but, in addition to the emanations themselves, their solid products of disintegration may float in the atmosphere, or be deposited upon bodies exposed to the air, and may thus contribute to the ionizing action. The flow of emanations from the ground to the air is affected by various factors. Gockel has called attention to the influence exerted upon this flow by moisture and freezing of the soil, and the effect of barometric pressure has already been mentioned. Hence the ionization of the air fluctuates greatly at the same place. It would be very interesting to observe these fluctuations systematically. For this purpose Ebert has devised an apparatus which makes a continuous record of the flow of ionizing emanations from the soil, together with the height of the thermometer and the barometer. The outflow of emanations shows a distinct daily variation and a less marked annual period. The daily maximum is observed at dawn, a smaller maximum at noon, and minima in the forenoon and afternoon.

The investigation of the radioactivity of mineral springs has made gratifying progress during the past year. Mache and Meyer have greatly improved the fontactoscope, which Engler and Sieveking devised for the measurement of the radioactivity of spring water. The most strongly radioactive spring which is known to exist is a spring of low temperature (55 deg. F.) in St. Joachimsthal. Its radioactivity is 2,050 Mache units. The second strongest spring is situated very near the first, but its activity is only 756 units. The third in strength is an old Roman spring in the Island of Ischia (372 units), the fourth is a spring in Joachimsthal (185 units). The activity of the remaining springs of Joachimsthal ranges from 14 to 59 units. A unique bathing establishment has been opened at Joachimsthal. The water of the most strongly radioactive springs are conducted together to the bath-house through pipes several miles in length. The strength of the mixed water is 600 units, a value far in excess of that of any natural water. The geological conditions in Joachimsthal have been thoroughly studied in connection with the radioactivity of springs, and the places likely to yield strongly radioactive water are known.

Conditions are different in the neighboring region of Saxony, in which great expectations were found. Here it has been learned that the most strongly radioactive water is not necessarily found in the vicinity of uranium ores. Several strongly radioactive springs of considerable volume have been found in places where the presence of uranium ores could not be proved and was not probable, while the waters of the abandoned uranium mines exhibit comparatively low radioactivity. These apparent contradictions are probably due to the fact that the water cannot always be examined at its place of origin. The strongest radioactive springs are found in granitic rocks, containing uranium mica. The most strong radioactive spring in Saxony has a strength of 73 Mache units. The radioactivity of springs in many other parts of Germany has been studied, but no spring comparable with those of Joachimsthal has been found.

The study of the radioactivity of springs is still in its infancy. The relation between the strength of the water and the character of the rocks which it traverses can never be fully explained, because the subterranean course of the springs, which often penetrate diverse geological strata, cannot be followed. Certain cardinal points, however, have been established. The strongest cold springs are found in granite and gneiss. Then follow, in order of diminishing strength, crystalline slates, clay and sandstone and, finally, limestone. It is also certain that the quantity of emanation is increased by recent volcanic eruptions. Strutt finds that the radioactivity of granite is due chiefly to the mica and the iron oxides which it contains.

Often neighboring springs, almost identical in chemical constitution, exhibit great differences in radioactivity. Sometimes this difference is due to the evolution of larger quantities of gas, which carries off the emanation, by one spring than by the other. Dienert and Bouquet found the activity of one spring to fluctuate periodically in accordance with the height and salinity of the ground water. The salinity decreased and the quantity of emanation in the water increased as the level of the ground water rose. Other meteorological factors may co-operate in the production of the frequently observed fluctuations in the radioactivity of springs. An exact study of these fluctuations would be of great importance. This study could probably be made most simply by means of a continuous registering apparatus analogous to that devised by Ebert for the emanations of the soil. When the activity of water is due to the presence of radium emanation, it may be expressed in cubic millimeters of emanation. One electrostatic unit of electricity corresponds to 2.1×10^{-10} cubic millimeters of radium emanation, or to 1,000 Mache units.—Condensed for SCIENTIFIC AMERICAN SUPPLEMENT from Zeit. f. ang. Chemie.

SCIENCE NOTES.

In Le Radium, A. Piutti publishes an account of his measurements of the amount of helium in the atmosphere. The paper deals with a sensitive method of estimating the amount of helium in the atmosphere and also in minerals. The principle of the method depends upon the absorption of the other gases than He by cocoanut charcoal immersed in liquid air, the He being estimated by the intensity of the various He lines in a spectroscope placed along the prolongation of a Plucker tube. Piutti has succeeded in detecting the presence of He in 3.5 cubic centimeters of the air at Naples, corresponding to an amount of He of the order 1/14 cubic millimeters. Piutti also gives details of measurements of the He given off when different zircons are heated; these measurements being compared with their radio-activity and density. Of the nineteen specimens examined the zircon from Vesuvius contained the smallest amount of He relative to its radio-activity, and that from Renfrew (Canada) the highest.

A patent has been taken out by C. Dreyfus, A. Friedl, W. H. Bentley, and the Clayton Aniline Company, Ltd., on the treatment of old vulcanized rubber. According to the patent, 500 pounds of finely vulcanized waste are mixed with 2,000 pounds of 10 per cent sulphuric acid, the mixture is agitated for 24 hours, and then boiled for 6 hours. Fibrous matter and a portion of the inorganic constituents are thus removed. The residue is washed with water and boiled for 3 to 5 hours with 1,500 pounds of 10 per cent sodium hydroxide, a further portion of the inorganic constituents, including all the uncombined sulphur, being thus eliminated. The residue is washed, pressed, dried, mixed with 3 to 5 times its weight of aniline (or a homologue thereof), and heated until agglomeration of the mass takes place, at a temperature of 140 deg. to 170 deg. C. The mixture is agitated during the heating process. The agglomerated mass is pressed to free it as far as possible from aniline, etc., the last portions of which are removed by means of any suitable pressing or washing machine. Rubber of high resiliency is obtained by this process.

In the Electrical World, Messrs. W. T. Vivian and G. W. Huey describe a portable phosphorescent photometer. This instrument was constructed out of an old illumination photometer by substituting a surface composed of luminous paint for the small glow-lamp and battery originally used. The brightness of this surface is compared with another illuminated by the source to be tested, and the light from the latter is very considerably reduced by suitable screens and a graduated aperture. A blue glass is also introduced in order to bring its color into agreement with that of the phosphorescent paint. Previous to using the photometer the coating of paint (chiefly calcium sulphide) is excited by exposure to a luminous source. Its resulting brightness after the light is shut off depends mainly on the intensity of this light and not very greatly on the time of exposure. However, the brightness gradually falls afterward. It was found possible to represent this fall very closely by a curve connecting brightness and time; this must be utilized to calculate the results when measurements are subsequently made with the photometer. The rate of diminution in brightness is very rapid. In roughly an hour it was reduced from 0.00015 to 0.00005 candle-centimeter units. The results are also very materially influenced by the temperature, and in order to secure consistent results it was found necessary to paint the outside of a metal receptacle, its interior being filled with chipped ice and water, so that the coating could be maintained at the temperature of melting ice. Apparently the previous history of the surface does not greatly influence its behavior after exposure has taken place.

TRADE NOTES AND FORMULÆ.

Varnish for Gold Moldings.—*a.* Seed lac 2 parts, gamboge 1 part, alcohol 14 parts. *b.* Seed lac 2 parts, sandarac 4 parts, elemi 4 parts, gamboge 2 parts, dragon's blood 2 parts, turmeric 1 part, alcohol 40 parts. *c.* Shellac 4 parts, sandarac 4 parts, mastic 1 parts, Venice turpentine 5 parts, rosin 1 part, dragon's blood 4 parts, alcohol 70 parts. *d.* Shellac 2 parts, seed lac 2 parts, annatto 2 parts, gamboge 6 parts, saffron 1 part, alcohol 15 parts.

Isinglass as Fining for Wine.—Cut the isinglass into small pieces with a scissors and lay it in water, which should be changed every 6 hours. When the isinglass is well swollen up (after 24 to 36 hours) pour over it a fluid mixture, consisting of 1,500 parts of 90 per cent alcohol, free from fusel oil; 8,500 parts of water, and 100 parts of tartaric acid, allow it to stand 6 hours, stir thoroughly, and press the pulpy mass through a cloth. The residue, remaining in the cloth, consisting of unswelled isinglass, is kept for use in the next operation.

Coloring Bronze (according to Hunt).—Dissolve dry chloride of platina in water until the solution contains about 1 part of platina in 5,000 parts of water. The objects, mordanted for one minute in a hot solution of 32 parts of cream of tartar in 5,000 parts of water, are rinsed off and moved about in the platina solution. As soon as a change in the color is apparent, dip the articles in a stronger platina solution heated to 109 deg. F., rinse after the appearance of the color and dry.

A Cheap Preventive of Dry Rot.—Apply chloride of zinc. To prepare the coating: dissolve 100 parts of crystallized white vitriol in 250 to 300 parts of water, add 50 parts of common salt, heat slightly and set to cool. Next day, the greater part of the sulphate of sodium formed, will have separated by crystallization. Pour off the chloride of zinc lye; the lye obtained will contain approximately 16 per cent of chloride of zinc. It can be colored, as desired, with Van Dyke brown and if the odor is not objectionable, about 5 per cent of phenolic acid may be added.

Varnish for Imitation Gold Moldings.—*a.* Shellac 1,500 parts, alcohol 3,000 parts. The solution *a* is prepared alone and allowed to clarify by settlement. *b.* Sandarac 250 parts, mastic 200 parts, gamboge 250 parts, dragon's blood 50 parts. The solution *b* is mixed with the shellac solution, poured off clear, and there is a certain scope possible in the color of the varnish. If, for instance, pale gold is to be reproduced, the quantity of dragon's blood above indicated will be sufficient; if, however, it is desired to impart to the varnish a color inclining more to red, the quantity of dragon's blood should be increased. It is particularly convenient, in the case of these varnishes, to prepare the solutions of gamboge and dragon's blood separately; it is easy then, by the addition of more or less of one or the other solutions, to impart to the varnish any desired shade of color.

To Etch Glass Dull (according to Lainer and Kampmann).—Mix 240 parts of commercial hydrofluoric acid (spec. grav. 1.2583) with 600 parts of powdered soda crystals and dilute with 1,000 parts of water. After prolonged standing, precipitate will have formed, with a supernatant solution. Provide perfectly cleansed flat glass with a wax rim made by kneading together yellow wax, tallow, rosin, and asphalt powder. Etch slightly in advance with ordinary hydrofluoric acid (1:10) wash with water and wipe the plate with a clean, soft sponge. The paste of the etching acid is stirred up and poured 0.5 to 1 centimeter deep on the glass plate. After an hour, it will be nicely frosted. Return the paste to the etching acid. Wash the glass plate off with water, allow the water to stand on the plate until a film (of silicate) formed on its surface, can be removed with brush or finger, then wash off with water and dry. The frosting effected may be rendered transparent, by etching off with hydrofluoric acid.

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